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TRANSACTIONS

OF THE

Thirty-second and Thirty-third Annual Meetings

OF THE

KANSAS ACADEMY OF SCIENCE.

(1899–1900.)

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VOLUME XVII.

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PROCEEDINGS.

THIRTY-SECOND ANNUAL MEETING OF THE KANSAS ACADEMY OF SCIENCE, DECEMBER 28-30, 1899.

McPHERSON, KAN., December 28, 1899.

The Kansas Academy of Science convened for the thirty-second annual meeting at McPherson, Kan. The opening session was held in the assembly hall of the high-school building.

The Academy was called to order by Vice-president A. S. Hitchcock, at 7:30 P. M., December 28, 1899.

The following-named members were present: E. H. S. Bailey, J. W. Beede, F. W. Bushong, H. J. Harnly, A. S. Hitchcock, A. W. Jones, Warren Knaus, D. E. Lantz, Ephraim Miller, F. O. Marvin, J. R. Mead, L. E. Sayre, J. E. Shacklett, A. J. Smith, and B. B. Smyth.

Vice-president Hitchcock appointed the following committees:

On program: Warren Knaus, D. E. Lantz, J. W. Beede.

On membership: L. E. Sayre, B. B. Smyth, H. J. Harnly.

For the information of members present, the minutes of the thirty-first annual meeting were read.

The committee on program made a report, which was adopted, and the following papers were then taken up and read:

1. The first great roof, by Chas. H. Sternberg. (Read by the secretary.)

2. *Apocynum cannabinum*, by L. E. Sayre.

3. Some geologic phenomena in central Missouri, by S. Z. Sharp. (Read by the secretary.)

The committee on members reported the following names for membership:

Prof. L. H. Shattuck, Holton.
J. C. Cooper, Topeka.
J. S. Dawson, Hill City.
L. D. Arnold, Salina.
H. W. Charles, Washington.
S. G. Mead, McPherson.
J. E. Welin, Lindsborg.

On motion, the above were duly elected. After announcements by the local members, the Academy adjourned, to meet at nine A. M. on Friday morning.

FRIDAY MORNING, December 29.

The Academy was called to order by Vice-president Hitchcock at nine o'clock A. M.

The following committees were appointed:

On nominations: J. R. Mead, E. Miller, F. W. Bushong.

On resolutions: E. H. S. Bailey, J. C. Cooper, L. D. Arnold.

On necrology: B. B. Smyth, Warren Knaus.

On auditing accounts of treasurer: A. W. Jones, F. O. Marvin, A. J. Smith.

The librarian made a verbal report of the work done during the past year. The report was accepted by vote.

The treasurer reported the amount of money on hand as $50.90. The report was referred to the auditing committee.

The committee on legislation appointed at the thirty-first annual meeting reported, through the chairman, D. E. Lantz. The report was accepted, and on motion the committee was continued.

The following were recommended for membership, and duly elected:

Mark White, Winfield.

C. F. Stafford, Lawrence.

The following papers were then presented:

1. On an ancient Pueblo village in western Kansas, by S. W. Williston. (Read by title.)

2. Secondary gypsum deposits in the United States, by G. P. Grimsley. (Read by title.)

3. Geology of the Glass mountains of western Oklahoma, by Mark White. (Read by the secretary.)

4. Silicified cement mortars, by Col. W. Tweeddale. (Read by B. B. Smyth.)

5. Home of the Kansas tiger beetles, by Warren Knaus.

6. On the heating value of coal, by E. H. S. Bailey.

7. Some Kansas pyrites, by J. C. Cooper.

Mr. Cooper showed some beautiful specimens of spherical nodules of pyrites which excited much interest.

On motion, the Academy adjourned, to meet at two o'clock P. M.

FRIDAY AFTERNOON, December 29.

The Academy was called to order at two P. M. by Vice-president Hitchcock.

The minutes of the session of Thursday evening were read and approved.

The membership committee reported favorably on the following named persons, and they were duly elected:

C. F. Gunderson, McPherson.

Lewis Hopkins, Salina.

The committee on membership also reported the following as entitled to life membership: E. Miller, S. A. Baldwin, I. D. Graham, D. M. Valentine. On motion, they were duly elected.

The question of time and place for the next annual meeting was made a special order for four o'clock.

The reading of papers was then continued.

11. On the Leonid meteors of 1833, by J. R. Mead.

12. An example of variation in the human cranium, by H. J. Harnly.

13. Additions to the flora of Kansas, by A. S. Hitchcock.

14. On testing paving bricks, by F. O. Marvin.

15. Mirages, by B. B. Smyth. (Read by title.)

16. An historical list of Kansas mammals, by D. E. Lantz. (By title.)

17. A plan for a small astronomical observatory, by E. B. Knerr. (By title.)

18. On the selachians of the Kansas Cretaceous, by S. W. Williston. (By title.)

19. Stratigraphy of southeastern Kansas, by Geo. I. Adams. (By title.)

20. On some Diatomaceæ of Topeka and vicinity, by Geo. H. Curtis.

21. Analysis of magnesia waters near Madison, by F. W. Bushong.

22. Technique in the study of Coccidæ, by S. J. Hunter and W. S. Sutton. (By title.)

23. Collecting notes from southwest Kansas, by Warren Knaus.

24. Additions to the list of Kansas Coleoptera, by Warren Knaus.

25. On the electrical conductivity of liquid ammonia solutions, by E. C. Franklin. (By title.)

At this point the question of time and place of the next meeting was taken up and discussed by several members. On motion, the matter was left to the executive board for decision.

The reading of papers was continued.

26. The softening and purifying of water by the Tweeddale proccess, by W. Tweeddale. (Read by title.)

27. *Melanoplus differentialis* and *M. bivittatus* in Kansas, by Hunter and Sutton. (By title.)

28. Notes of a trip through western Wyoming, by J. R. Mead.

29. The host-plants of Kansas Coccidæ, by P. J. Parrott. (By title.)

30. The orthopteran genus *Melanoplus* in Kansas, by Hunter and Sutton. (By title.)

31. A comparison of the faunas of the Permian in England and America, by J. W. Beede.

32. Harmonic forms, by B. B. Smyth.

33. A geological section of Lyon and Chase counties along the Cottonwood river, by A. J. Smith.

On motion, adjourned until 7:30 P. M.

FRIDAY EVENING, December 29.

The Academy met in the assembly hall of the high school at 7:30 P. M.

The minutes of the morning and afternoon sessions were read and approved.

Miss Grace R. Meeker, Ottawa, having been recommended by the committee, was elected to active membership.

The committee on nominations recommended the following for officers of the Academy for the ensuing year:

President, A. S. Hitchcock, Manhattan.

First vice-president, Ephraim Miller, Lawrence.

Second vice-president, J. C. Cooper, Topeka.

Secretary, D. E. Lantz, Chapman.

Treasurer, J. W. Beede, Effingham.

Librarian, B. B. Smyth, Topeka.

Curators, B. B. Smyth, Topeka; Warren Knaus, McPherson; G. P. Grimsley, Topeka; Edward Bartow, Lawrence.

On motion, they were duly elected.

The committee on resolutions presented the following, and, on motion, it was adopted:

Resolved, That the hearty thanks of the Academy are hereby tendered to the faculty of McPherson College and the citizens of McPherson for their hospitality; and to the authorities of the high school and the newspapers of the city for numerous favors extended.

E. H. S. BAILEY,
J. C. COOPER,
L. D. ARNOLD,
Committee.

The auditing committee reported that they had examined the accounts of the treasurer and found them to be correct. The report was accepted.

The committee on necrology reported that no members of the Academy had died during the past year.

34. Prof. E. Miller then read a paper entitled "The Corona of the Sun." The lecture was illustrated with numerous lantern views.

The address of the retiring president, E. B. Knerr, was then presented by the secretary, Professor Knerr having been detained at home by the illness of his wife.

On motion of Doctor Sayre, the secretary was directed to convey to Professor Knerr an expression of the appreciation of the address by the members of the Academy.

Other papers presented were:

35. Some further remarks on the Mentor Beds, by A. W. Jones. (By title.)

36. On some public water-supplies, by E. H. S. Bailey. (By title.)

37. A contribution to the origin of gypsum beds, by E. H. S. Bailey and M. K. Shaler.

38. Ecological areas in Florida flora, by A. S. Hitchcock. (By title.) An oral abstract of the paper was given by the author.

The minutes of the present session were read and approved.

On motion, adjourned to meet at nine o'clock Saturday morning, in the parlor of the Commercial hotel.

SATURDAY MORNING, December 30.

The Academy met pursuant to adjournment; President Hitchcock in the chair.

J. H. Newby, Osage City, Kan., was elected to active membership.

A motion was passed requesting Profs. F. O. Marvin and A. S. Hitchcock to deliver lectures before the Academy at Topeka during the coming year, and that the arrangements for the lectures be left to the executive committee.

On motion, adjourned *sine die*. D. E. LANTZ, *Secretary*.

THIRTY-THIRD ANNUAL MEETING OF THE KANSAS ACADEMY OF SCIENCE, DECEMBER 28-29, 1900.

TOPEKA, KAN., December 28, 1900.

The Kansas Academy of Science met for the thirty-third annual meeting at Topeka. The opening session was held in the old supreme court-room, in the state-house.

The Academy was called to order by President Hitchcock at ten o'clock A. M., December 28, 1900.

The following members were present: E. H. S. Bailey, W. C. Bauer, J. W. Beede, R. B. Dunlevy, C. N. Gould, C. F. Gustafson, H. J. Harnly, A. S. Hitchcock, Warren Knaus, E. B. Knerr, D. E. Lantz, J. R. Mead, Grace Meeker, E. Miller, W. K. Palmer, L. E. Sayre, L. H. Shattuck, Alva J. Smith, B. B. Smyth, A. H. Thompson, J. D. Walters, J. T. Willard, J. E. Welin, L. C. Wooster. A number of visitors were also present.

The record of business transacted at the last meeting of the Academy was read by the secretary.

The president appointed the following committees:

On program: C. N. Gould, D. E. Lantz, H. J. Harnly.

On membership: J. W. Beede, L. C. Wooster, W. C. Bauer.

The reading of papers was then taken up in the order presented by the preliminary program.

1. The spring flora of Cowley county, by Mark White. (Read by the secretary, in the absence of the author.)

2. Magnetic measurements at the Baldwin magnetic observatory of the United States coast and geodetic survey, by Wm. C. Bauer.

3. Additions to the list of Kansas Coleoptera during 1899–1900, by Warren Knaus.

4. The relative rate of digestion of raw vegetable proteids and cooked, by J. T. Willard and Maud Gardiner. (Read by J. T. Willard.)

5. The Muscotah artesian wells, by E. B. Knerr.

6. The Atchison diamond-drill prospect hole, by A. E. Langworthy. (Read by title, in the absence of the author.)

7. Salt plains in Oklahoma, by C. N. Gould.

The following were read by title or abstracts given by the authors:

8. Catalogue of the Goss ornithological collection, by B. B. Smyth.

9. List of birds observed in Dickinson county, by D. E. Lantz.

10. List of plants collected in Lee county, Florida, by A. S. Hitchcock.

11. List of plants in my Florida herbarium, part II, by A. S. Hitchcock.

On motion of L. E. Sayre, a committee of five was appointed to consider the welfare of the Academy, and to report at a later session of this meeting. The following were appointed members of the committee by acclamation: E. H. S. Bailey, A. H. Thompson, D. E. Lantz, A. S. Hitchcock, Warren Knaus.

After announcements for the afternoon meeting the Academy adjourned, to meet at two o'clock P. M.

FRIDAY AFTERNOON, December 28.

President Hitchcock called the Academy to order at two P. M. He appointed the following committees:

On necrology: A. H. Thompson, E. Miller.

On nominations: J. T. Willard, E. H. S. Bailey, E. B. Knerr.

On resolutions: W. K. Palmer, A. J. Smith.

Auditing accounts: J. R. Mead, L. E. Sayre, Warren Knaus.

The committee on membership reported, recommending the following: J. M. Westgate, Manhattan; Carl Johns, Lindsborg; J. A. Harris, Lawrence; L. N. Morscher, Lawrence; Arthur Ringer, Baldwin; S. A. Diel, Baldwin; E. N. Johnson, Holton.

On motion, they were duly elected to active membership.

Papers were then presented as follows:

12. Collecting notes on Kansas Coleoptera, by Warren Knaus.

13. Soil exhaustion by continuous cropping of wheat, by J. T. Willard.

14. The value of graphical methods in teaching thermodynamics, by W. K. Palmer.

15. Some recent experiments with liquid ammonia as a solvent, by E. C. Franklin and C. A. Kraus. (Read by Mr. Franklin.)

16. Americus limestone, by A. J. Smith.

17. On the southern extension of the Marion and Wellington formations, by C. N. Gould.

18. Additional notes on medicinal plants of Kansas—medicinal agents of the Asclepiadaceæ, by L. E. Sayre.

19. The effect of oxygen on animal life, by J. T. Willard and A. T. Kinsley. (Read by Mr. Willard.)

20. Dakota Cretaceous of Kansas and Nebraska, by C. N. Gould. (Read by title.)

21. Some Diatomaceæ of Reno county, Kansas, by Geo. H. Curtis. (Read provisionally by title, the author having been detained at home by illness.)

22. The Flint Hills, by J. R. Mead.

23. The use of ball bearings for general machinery, by W. K. Palmer.

24. A new Cretaceous turtle, by S. W. Williston.

The committee on membership reported, recommending E. H. Sellards, Lawrence; D. F. McFarland, Lawrence; and C. H. Martin, Topeka.

On motion, they were elected to active membership.

On motion, adjourned until eight o'clock P. M.

FRIDAY EVENING, December 28.

The Academy met in the senate chamber.

Pres. A. S. Hitchcock gave the annual address, choosing as a subject "A Brief Outline of Ecology."

Prof. E. Miller gave a lecture on "The Milky Way," illustrated with many lantern slides.

Prof. G. P. Grimsley delivered a lecture on "The Mines and Minerals of Kansas," illustrated with numerous lantern slides.

On motion, the Academy adjourned, to meet at nine o'clock A. M., Saturday.

SATURDAY MORNING, December 29.

The Academy met in the senate chamber, and was called to order by President Hitchcock.

The minutes of the sessions of Friday were read and approved.

The committee on nominations presented the following report:

For president, E. Miller, Lawrence.

First vice-president, J. C. Cooper, Topeka.
Second vice-president, L. C. Wooster, Emporia.
Secretary, D. E. Lantz, Alma.
Treasurer, E. C. Franklin, Lawrence.
Librarian, B. B. Smyth, Topeka.
Curators: B. B. Smyth, Topeka; Warren Knaus, McPherson; G. P. Grimsley, Topeka; Edward Bartow, Lawrence.

On motion, the report was laid on the table to await the report of the committee on the welfare of the Academy.

The secretary read the following letter to the librarian from Rev. Jno. D. Parker, one of the founders of the Academy:

Prof. B. B. Smyth: EAST ORANGE, N. J., December 20, 1900.

DEAR SIR—I have received the "preliminary program" of the thirty-third annual meeting of the Kansas Academy of Science, and it stirs memories of the olden time. It does not seem a third of a century since Professor Mudge and I, with a few local attendants (called out for the occasion), organized, in my lecture-room in Lincoln College, the Kansas Natural History Society, which was afterward enlarged in its scope and became the Kansas Academy of Science. That was the beginning; but Professor Mudge said: "We must not despise the day of small things." Sometimes I would make a motion, and Professor Mudge would second it and put it to vote, and when we both voted for it the motion was carried *unanimously*. That was a blessing to have perfect unanimity. At the second annual meeting, held in the Topeka Presbyterian church, I secured half rates on the Kansas Pacific railway for those attending the meeting, provided the secretary signed the return ticket. I remember signing the return ticket of just one man, who came into the meeting a few minutes to meet the requirements of the railway.

Scientists were scarce in those days, and to a scientist there were "chunks of solitude"; but I do not want you to think that Professor Mudge and I were not happy. I think we had more substantial enjoyment than any other two persons in Kansas. It was easy to run down to Lawrence, and Professor Snow was the prince of good fellows. You remember that where Lord Brougham sat "there was the head of the table," and where Professor Mudge sat there was the head of the table. He had an inexhaustible fund of knowledge, which was enlivened by incidents arising out of his wide and varied experiences. He was one of the most charming lecturers in the West. Once he gave a lecture on the "Geology of Kansas" in my church in Burlington, Kan., and he held the audience spell-bound until he finished. I remember some amusing incidents of his life.

Professor Mudge was very fond of pepper, and one time, while eating and shaking the pepper-box over his plate, the top came off suddenly and nearly all the pepper came out of the box on his food. That day I noticed the professor was especially lively, but sometimes tears would come into his eyes. I read of a man who, having never seen red pepper, put a teaspoonful into his mouth to sample it. When tears came into his eyes he was asked what stirred his emotions. He replied that he was thinking of his grandfather. I suppose Professor Mudge must have been working up his genealogical record that day, for he seemed to have very tender emotions.

One day, while visiting Professor Mudge at Manhattan, we went to an Indian burial-place and took out of a grave a skeleton, and a brass kettle placed in the grave that the deceased Indian could use as he went to the happy hunting-grounds.

The broken skeleton was placed in the kettle which was put in the back end of the wagon often used by the professor on geological excursions. On returning to his home I looked back in the wagon and saw the bones in the kettle, and told the professor it reminded me of a passage of scripture. He asked what passage. I told him it was recorded in 2 Kings iv: 40: "O thou man of God, there is death in the pot."

Perhaps you may remember that Professor Mudge lived very much in the past, and knew almost everything in geological history, but did not always keep up with current events. One time he was visiting us at the institution for the blind, at the time of meeting of the board of trustees. We were all sitting at the long table in the dining-room—the trustees, teachers, Professor Mudge, and my family. Professor Mudge was deploring the fact that writers in Eastern papers would misrepresent Kansas and exaggerate. One of the trustees asked him to give some example where a writer had exaggerated. "Well," said the Professor slowly, in his sober, unassuming way, trying to call up an example, "recently I saw a letter in an Eastern paper where a writer, in describing the grasshopper scare, actually stated that when the grasshoppers visited Kansas they were three feet deep at Topeka." The trustee asked him who wrote the article. Professor Mudge replied that he had almost forgotten the name of the writer; but after a moment he added, trying to recall it, "I believe it was Eli—Eli—it seems to me it was Eli Perkins!" The whole company, of course, burst into a roar of laughter, and Professor Mudge, whose awakened memory and quick perception took in the situation, laughed as heartily as the others. We all agreed with Professor Mudge in his proposition that writers would sometimes exaggerate, but the example given of a humorist did not prove it.

The thousand dollars which the friends of science put into Professor Mudge's monument at Manhattan was simply a token of the deep and abiding love which all classes felt for him. His large scientific knowledge; his modesty and unassuming manners; his purity of character and sweetness of disposition; his wonderful activity, both physical and mental, up to the day of his death—for when he received the paralytic stroke that terminated his life he was preparing one of his charming lectures—all of these things give him a place and a name that will remain sacred in Kansas as long as science is cultivated on the great central plains of North America. I remember that Chancellor Snow once said that Professor Mudge was about equal to three ordinary men.

Well, I want you to tell all the members of the Kansas Academy of Science that my heart goes out to them wonderfully. In all my scientific work, no scientists have come quite so close to me, and been so dear to my heart, as those in Kansas. I wish I could attend the meeting at Topeka. How the recollections rush upon me as I think of the scientific associations which it has been my privilege to originate, viz.:

Kansas Academy of Science,
Kansas City Academy of Science,
Nebraska Academy of Science, and
California Science Association.

Out of these, I am told, have sprung the
Indiana Academy of Science and
Ohio Academy of Science.

These are the children and grandchildren of a wonderful scientific family. The field of all these associations covers a third of a million square miles; ten millions of people live in it; and a thousand scientists are connected with these associations, it is estimated. What hath God wrought in the West, by the humblest instrumentality! Fraternally, JOHNS D. PARKER.

On motion of Doctor Williston, the letter was ordered published in the proceedings of the Academy.

The committee on the welfare of the Academy presented the following report:

To the Members of the Kansas Academy of Science:

Your committee to whom was entrusted the consideration of the general welfare of the society beg leave to make the following report:

First.—We recognize the great value of the library to the members of the Academy and to the people of the state at large. For the small appropriations and amount expended in printing, a very large amount of most valuable material is received in the way of exchanges; indeed, an amount far in excess of the cost of our own publications. We believe that every effort should be made to increase the library: and when some plan is formulated for the consolidation of all the libraries in the state-house under a common head we should favor having the Kansas Academy library made a part of this collection.

Second.—We consider the Goss collection of birds very valuable for instructional purposes and as such it should be made more available by having larger cases provided, to relieve the crowded condition of the collections. This collection requires the constant care of some competent person in order to keep it in good condition.

Third.—We urge at as early a period as possible the establishment and maintenance by the Academy of an economic museum of the industrial products of the state for popular instruction. We have already the basis for such a collection, and we realize that it will be of great interest and value in the development of our resources, and will attract the attention of those desirous of investing capital in the state. We believe that the collection for the museum of specimens other than those having a distinct industrial value should be for the present discouraged.

Fourth.—We believe that the value of our publications both to our own members and to the scientific world would be doubled if these publications could be issued promptly. We suggest, therefore, that an effort be made to issue bulletins containing the most important papers whenever they are offered for publication, and that these bulletins be serially numbered, paged, and indexed, so as to be convenient for binding. By this means we should secure for the Academy many valuable papers which at present are sent to other journals. The Academy does not attract many important papers that would give it a higher standing in the scientific world.

Fifth.—We suggest that the secretary keep himself informed in regard to all persons in the universities, colleges and high schools of the state, and all other persons interested in science, and that a persistent effort be made to secure their cooperation in forwarding the work of the Academy.

Sixth.—We recommend that such changes be made in the constitution of the Academy as that the officers shall be a president, two vice-presidents, a secretary, a treasurer, and an editor. We suggest that the secretary be a salaried officer, and that he have charge of all the books, collections and material properly belonging to the Academy. We suggest that the editor be chairman *ex officio* of a committee of three who shall have the entire responsibility of issuing the proceedings of the Academy.

Seventh.—We ask for the following annual appropriations from the legislature: For the salary of secretary, including help of a stenographer, $1200; for new mu-

s'um cases for the Goss collection and for the industrial collections referred to above, $500; for postage, express, etc., $300; total, $2000.

Respectfully submitted.

E. H. S. Bailey, A. S. Hitchcock,
W. Knaus, D. E. Lantz,
A. H. Thompson, *Committee.*

The report was taken up by sections, and, after slight amendments, was adopted as presented above.

The report of the committee on nominations was taken from the table, and, on motion, the persons nominated were duly elected, the secretary casting the ballot.

The treasurer reported a balance of $124.90 on hand.

On motion of B. B. Smyth, fifty dollars was set aside for use of the executive committee in furnishing illustrations for next report.

The reading of papers was then continued.

26. Sanitary water analysis at Kansas University, by Edward Bartow. (Read by Prof. E. H. S. Bailey.)

27. Wild flowers of Kansas adapted to cultivation, by Grace R. Meeker.

28. Contributions toward a monograph of the Permian of the central United States: (1) The Permian of the Blue Valley and its fauna, by J. W. Beede.

29. The food of fishes in central Kansas, by Geo. H. Curtis. (Read by title.)

30. The Kansas-Oklahoma Triassic and its invertebrate fauna, by C. N. Gould and J. W. Beede.

31. A new method for the identification of arsenic, antimony, and tin, by H. P. Cady. (Presented by E. H. S. Bailey.)

32. The Atchison shales, by J. W. Beede.

33. A new mangano-ferrous mineral water, by E. H. S. Bailey.

On motion, adjourned to meet at 1:30 P. M.

SATURDAY AFTERNOON, December 29.

The Academy was called to order by President Hitchcock at 1:30 o'clock P. M.

B. B. Smyth and F. W. Cragin, having been members of the Academy for twenty years, were, on recommendation of the committee on membership, elected as life members.

F. F. Crevecœur, of Onaga, was proposed for membership and duly elected.

On motion, Prof. George T. Fairchild, of Berea, Ky., was elected to honorary membership in the Academy.

The reading of papers was then continued.

34. Archeology of Catalina island, by J. R. Mead.

35. Principles of chimney design, by W. K. Palmer.

36. Catalogue of the Quintard conchological collection, by B. B. Smyth. (Read by title.)

37. The black duck (*Anas obscura*) in Kansas, by R. Matthews. (Presented by D. E. Lantz.)

The auditing committee reported that the accounts of the treasurer were correct. The report was accepted and the committee discharged.

The president appointed, as a committee on legislation, Dr. S. W. Williston, D. E. Lantz, and Dr. A. H. Thompson.

Mr. B. B. Smyth announced that the Quintard collection of shells had come into the custody of the curators of the Academy, to be exhibited in the state museum.

On motion, a committee of three was appointed to consider the proper acceptance of the gift and act thereon. The president appointed D. E. Lantz, E. A. Popenoe and B. B. Smyth members of said committee.

The following papers were then presented:

38. Kansas climate and crop review, 1900, by T. B. Jennings. (Read by title.)

39. Annotated catalogue of the crayfishes of Kansas, by J. A. Harris. (Abstract given by the author.)

40. The role of isostasy, by L. N. Morscher.

41. Fossil plants from the Permian of Kansas, by E. H. Sellards.

The committee on resolutions reported the following:

Resolved, By the Kansas Academy of Science, in session at Topeka, Kan., December 29, 1900, that the thanks and appreciation of the Academy be and are hereby extended to the officers of the state-house for the accommodations and conveniences kindly afforded the Academy during its sessions, and to the press of Topeka for its courtesies to the Academy; and the secretary is hereby instructed to transmit a copy of this resolution to the officials to whom the Academy is indebted and to the Topeka press.

W. K. PALMER.
A. J. SMITH.

Prof. E. H. S. Bailey gave written notice of a change in the constitution to embody the recommendations of the committee adopted by the Academy at the morning session.

The time and place for the next annual meeting of the Academy were, on motion, referred to the executive committee for action.

The minutes were then read and approved.

On motion, the Academy took a recess until eight o'clock P. M., January 25, 1901.

TOPEKA, KAN., January 25, 1901.

The Kansas Academy of Science met pursuant to adjournment of December 29, 1900, Pres. E. Miller in the chair.

President Miller stated the object of the present adjourned session.

Prof. F. O. Marvin delivered a lecture on "Water-supply from a Sanitary Standpoint."

On motion of Professor Sayre, the lecturer was asked to permit the Academy to publish his lecture in the forthcoming volume of "Transactions."

A special order of business was the consideration of the amendment to the constitution proposed on December 29 by Prof. E. H. S. Bailey.

Moved by Professor Bailey to amend section 4 of the constitution so that it shall read:

> The officers of this Academy shall be chosen by ballot at the annual meeting, and shall consist of a president, two vice-presidents, a secretary, and a treasurer, who shall perform the duties usually pertaining to their respective offices. The president, secretary, and treasurer shall constitute an executive board. The secretary shall have charge of all the books, collections, and material properly belonging to the Academy.

The amendment was adopted by a vote of ten to two.

On motion, the sixth by-law was amended by substituting the word "secretary" for the word "librarian."

The secretary was instructed to report a revision of the constitution and by-laws to the Academy at the next annual meeting.

Professor Sayre announced that an invitation had been received from the city of Iola, asking that the next meeting of the Academy be held there.

On motion, the Academy adjourned *sine die*.

D. E. LANTZ, *Secretary*.

CONSTITUTION AND BY-LAWS OF THE ACADEMY.

CONSTITUTION.

SECTION 1. This association shall be called the Kansas Academy of Science.

SEC. 2. The objects of this Academy shall be to increase and diffuse knowledge in the various departments of science.

SEC. 3. Members of this Academy shall consist of two classes, active and honorary (including associate). *Active members* may be annual or life members. *Annual members* may be elected at any meeting of the Academy, and shall sign the constitution and pay a fee of one dollar and annual dues of one dollar; but the secretary, treasurer and librarian shall be exempt from the payment of dues during the years of their service. Any person who shall at one time contribute twenty dollars to the funds of this Academy may be elected a *life member* of the Academy, free of assessment. Any member who has paid dues to the Academy for ten consecutive years, or who has been legally exempt during any portion of that time, may be elected a *life member* on the payment of ten dollars. Any member who has been a member of this Academy in good standing for twenty years may be elected a *life member* without payment of further fees or dues. *Honorary members* may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a two-thirds vote of members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on applications for membership, who shall consider such application and report to the Academy before the election.

SEC. 4. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall consist of a president, two vice-presidents, a secretary, and a treasurer, who shall perform the duties usually pertaining to their respective offices. The president, secretary, and treasurer shall constitute an executive board. The secretary shall have charge of all the books, collections, and material properly belonging to the Academy.

SEC. 5. Unless otherwise directed by the Academy, the annual meeting shall be held at such time and place as the executive committee shall designate. Other meetings may be called at the discretion of the executive committee.

SEC. 6. This constitution may be altered or amended at any annual meeting, by a vote of three-fourths of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

I. The first hour, or such part thereof as shall be necessary, in each session, shall be set aside for the transaction of the business of the Academy. The following order of business shall be observed as far as practicable:

1. Opening.
2. Reports of officers.
3. Reports of standing committees.
4. Appointment of special committees.
5. Unfinished business.
6. New business.
7. Reports of special committees.
8. Election of officers.
9. Election of members.
10. Program.
11. Adjournment.

II. The president shall deliver a public address on the evening of one of the days of the meeting, at the expiration of his term of office.

III. No meeting of this Academy shall be held without a notice of the same having been published in the papers of the state at least thirty days previous.

IV. No bill against the Academy shall be paid by the treasurer without an order signed by the president and secretary.

V. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the treasurer, shall have their names stricken from the roll.

VI. The secretary shall have charge of the distribution, sale and exchange of the published transactions of the Academy, under such restrictions as may be imposed by the executive committee.

VII. Eight members shall constitute a quorum for the transaction of business.

VIII. The time allotted to the presentation of a single paper shall not exceed fifteen minutes.

IX. No paper shall be entitled to a place on the program unless the manuscript, or an abstract of the same, shall have been previously delivered to the secretary.

MEMBERSHIP JANUARY 1, 1901.

OFFICERS.

Elected December 29, 1900.

President	Ephraim Miller	Lawrence.
Vice-presidents	J. C. Cooper	Topeka.
	L. C. Wooster	Emporia.
Secretary	D. E. Lantz	Manhattan.
Treasurer	E. C. Franklin	Lawrence.
Librarian	B. B. Smyth	Topeka.
Curators	B. B. Smyth	Topeka.
	Warren Knaus	McPherson.
	G. P. Grimsley	Topeka.
	Edward Bartow	Lawrence.

HONORARY MEMBERS.

Rev. Johns D. Parker, Post Chaplain	East Orange, N. J.
Arnold B. Johnson, Lighthouse Board	Washington, D. C.
W. A. Kellerman, Ph. D., Ohio University	Columbus, Ohio.
Edw. L. Nichols, Ph. D., Cornell University	Ithaca, N. Y.
W. S. Franklin, Ph. D., Lehigh University	South Bethlehem, Pa.

ASSOCIATE MEMBERS.

Mrs. Mary E. Mudge	Manhattan.
Mrs. Mary Savage	Lawrence.

LIFE MEMBERS.

S. A. Baldwin	Wabaunsee.
F. W. Cragin, M. S., Colorado College	Colorado Srings, Colo.
I. D. Graham, B. A	Topeka.
Joseph T. Lovewell, Ph. D	Topeka.
Peter McVicar, D. D., Washburn College	Topeka.
J. R. Mead	Wichita.
Ephraim Miller, Ph. D., Kansas University	Lawrence.
Edwin A. Popenoe, M. A., Agricultural College	Manhattan.
B. B. Smyth, Academy of Science	Topeka.
Francis H. Snow, Ph. D., Kansas University	Lawrence.
A. H. Thompson, D. D. S	Topeka.
D. M. Valentine, LL. D	Topeka.
S. W. Williston, Ph. D., Kansas University	Lawrence.

ACTIVE MEMBERS.

Geo. I. Adams, Ph. D	Washington, D. C.
Orr Adams	Telluride, Colo.
L. D. Arnold, Salina Normal University	Salina.
E. H. S. Bailey, Ph. D., Kansas University	Lawrence.
Elam Bartholomew, M. S	Rockport.
Edward Bartow, Ph. D., Kansas University	Lawrence.
Wm. C. Bauer, A. M., Baker University	Baldwin.
J. W. Beede, Ph. D., University of Indiana	Bloomington, Ind.
Lucien I. Blake, Ph. D., Kansas University	Lawrence.
S. R. Boyce, Ph. G	Ann Arbor, Mich.

Davis Boyles	Salina.
C. M. Breese, M. S	Manhattan.
Arthur Bridwell, Baker University	Baldwin.
J. C. Bridwell, Baker University	Baldwin.
L. P. Brous	Torreon, Mex.
W. Barnum Brown	Costa Rica.
Edw. Bumgardner, M. D	Lawrence.
F. W. Bushong, B. S., Chicago University	Chicago, Ill.
H. P. Cady, B. A., Kansas University	Lawrence.
Chas. S. Caldwell	San Jose, Costa Rica.
M. A. Carleton, M. S., Agricultural Department	Washington, D. C.
E. C. Case, Ph. D	Milwaukee, Wis.
H. W. Charles, superintendent city schools	Washington, Kan.
T. D. A. Cockerell, Ph. D	East Las Vegas, N. M.
J. C. Cooper	Topeka.
H. M. Cottrell, Agricultural College	Manhattan.
W. R. Crane, A. M., Kansas University	Lawrence.
F. F. Crevecœur	Onaga.
F. B. Dains, B. S., Chicago University	Chicago, Ill.
John S. Dawson	Hill City.
S. A. Diel, Baker University	Baldwin.
R. B. Dunlevy, B. S., Southwest Kansas College	Winfield.
A. St. C. Dunstan, C. E	Auburn, Ala.
L. L. Dyche, M. S., Kansas University	Lawrence.
Frank Ellsworth	Effingham.
Arnold Emch, Ph. D	Boulder, Colo.
D. E. Esterly, M. D	Topeka.
B. F. Eyer, Agricultural College	Manhattan.
Frank E. Forbes	Topeka.
E. C. Franklin, Ph. D., Kansas University	Lawrence.
C. N. Gould, University of Oklahoma	Norman, Okla.
G. P. Grimsley, Ph. D., Washburn College	Topeka.
C. F. Gustafson, McPherson College	McPherson.
H. J. Harnly, B. S., McPherson College	McPherson.
J. Arthur Harris	Lawrence.
W. A. Harshbarger, B. S., Washburn College	Topeka.
Erasmus Haworth, Ph. D., Kansas University	Lawrence.
E. H. Heacock, B. S., high school	Topeka.
H. V. Hinckley, C. E.	Topeka.
A. S. Hitchcock, M. S., Agricultural Department	Washington, D. C.
C. B. Hoffman	Enterprise.
Ross Hopkins	Baltimore, Md.
S. J. Hunter, A. M., Kansas University	Lawrence.
Theo. M. Iden, Normal School	Emporia.
T. B. Jennings, U. S. Weather Bureau	Topeka.
Carl Johns, Bethany College	Lindsborg.
E. N. Johnson, Campbell University	Holton.
A. W. Jones, B. S., Wesleyan University	Salina.
Hugo Kahl, Kansas University	Lawrence.
V. L. Kellogg, M. S., Leland Stanford Jr. University	Palo Alto, Cal.
W. H. Keller	Wetmore.
D. S. Kelly, A. M	Emporia.

Warren Knaus, M. S.	McPherson.
E. B. Knerr, Sc. D., Midland College	Atchison.
C. A. Kraus, B. S.	Lawrence.
A. E. Langworthy	Atchison.
D. E. Lantz, M. S.	Manhattan.
W. N. Logan, B. S.	Beloit.
D. F. McFarland	Lawrence.
C. L. Marlatt, M. S., Agricultural Department	Washington, D. C.
F. A. Marlatt, M. S.	Manhattan.
Chas. H. Martin	Topeka.
F. O. Marvin, C. E., Kansas University	Lawrence.
R. Matthews, D. D. S.	Wichita.
S. G. Mead	McPherson.
Grace R. Meeker	Ottawa.
C. F. Menninger, M. D.	Topeka.
Mrs. A. H. Merrell	Topeka.
Benj. L. Miller, B. A., Penn College	Oskaloosa, Iowa.
L. N. Morscher	Lawrence.
E. C. Murphy, C. E., Kansas University	Lawrence.
H. L. Nelson, Washburn College	Topeka.
J. H. Newby	Osage City.
H. B. Newson, Ph. D., Kansas University	Lawrence.
A. M. Nissen, A. M., public school	Wetmore.
Matthew Noll, Ph. G.	Atchison.
J. B. S. Norton, B. S., Missouri Botanical Garden	St. Louis, Mo.
D. H. Otis, M. S., Agricultural College	Manhattan.
Walter K. Palmer, M. E., Kansas University	Lawrence.
C. S. Parmenter, A. M., Baker University	Baldwin.
Percy J. Parrott, A. B.	Chicago, Ill.
C. W. Pratt	Howard.
J. M. Price, jr., B. S.	Atchison.
C. S. Prosser, M. S., University of Ohio	Columbus, Ohio.
E. G. Pultzer, Baker University	Baldwin.
Minnie Reed, M. S., high school	Santa Ana, Cal.
E. S. Riggs, A. M.	Chicago, Ill.
Arthur Ringer	Baldwin.
W. R. Ringle, Kansas University	Lawrence.
W. G. Riste, B. S , high school	Colby.
F. H. Rose, Southwest Kansas College	Winfield.
L. E. Sayre, Ph. M., Kansas University	Lawrence.
E. H. Sellards	Lawrence.
J. E. Shacklett	Fall River.
S. Z. Sharp, A. M., Plattsburg College	Plattsburg, Mo.
L. H. Shattuck, Campbell University	Holton.
E. T. Shelly, M. D.	Atchison.
Alva J. Smith	Emporia.
O. F. Stafford	Eugene, Ore.
J. W. Stailey	Lawrence.
Chas. H. Sternberg	Lawrence.
W. C. Stevens, M. S., Kansas University	Lawrence.
Alban Stewart, B. A	Washington, D. C.
Sutton, W. S.	Lawrence.

W. T. Swingle, M. S., Agricultural Department..... Washington, D. C.
F. J. Titt, B. S., Kingfisher College..... Kingfisher, Okla.
E. E. Tyler, M. S., Polytechnic Institute..... Lincoln, Neb.
Geo. Wagner, Ph. C., Kansas University..... Ann Arbor, Mich.
J. D. Walters, M. S., Agricultural College..... Manhattan.
M. L. Ward, D. D., Ottawa University..... Ottawa.
Geo. F. Weida, Ph. D., Agricultural College..... Manhattan.
J. E. Welin, Bethany College..... Lindsborg.
J. M. Westgate, Agricultural College..... Manhattan.
Mark White, Southwest Kansas College..... Winfield.
J. T. Willard, M. S., Agricultural College..... Manhattan.
J. W. Wilson, B. S., high school..... Effingham.
L. C. Wooster, Normal School..... Emporia.
J. A. Yates, Ph. D., Ottawa University..... Ottawa.

TRANSACTIONS.

I. PRESIDENTIAL ADDRESSES.

A THEORY OF THE COSMOS.

BY E. B. KNERR, OF MIDLAND COLLEGE, ATCHISON, KAN.

An address delivered at McPherson, December 29, 1899, before the thirty-second annual meeting of the Kansas Academy of Science.

Man's attitude to the external world has ever been that of a great question mark, and at no time in the history of the race has mere assertion carried so little weight as at the present time. Every statement must be backed by some evidence of truth, some argument for its validity. New knowledge is always built on previous knowledge; and both are accepted only in so far as they are confirmatory of each other.

Among the very first questions which come to the inquiring mind are: How came this world into being? Whence the sun, the moon, the stars? What is this material world about us, anyway? What child has not queried about the support of the earth? These questions are not only put to-day, but they claimed the thought of milleniums ago. Never was question put, however, but some answer was evolved by poet or sage. Thus, many of the legends, heathen and Christian, accounting for the phenomenal world are rich in poetic beauty, and they have soothed the questioning mind, if they have not always entirely satisfied it.

It would doubtless be of much interest right here to recall some of the ideas that have prevailed among various peoples as to the origin of the earth and heavens, and the destiny of their inhabitants; but I shall refrain from so doing, and proceed at once to a consideration of a view of the universe warranted, in my opinion, by the revelations of modern science.

Notwithstanding the great diversity everywhere manifest in the universe, there is an essential unity in it all. The very name "universe" implies such unity. Everything is under the reign of law. There is a wonderful harmony in it all.

The cosmos is defined as "the world or universe considered as a system, perfect in order and arrangement; opposed to chaos."

Our purpose now is to investigate this "order," and so far as possible discover the laws manifest in this "arrangement." Some of these laws have been recognized for ages; others are of more recent discovery. Such are Newton's laws, Kepler's laws, Avogadro's law, Dalton's law, Lane's law, etc. It is not meant that these laws govern the movements and states of matter as a civil law governs the citizens of a state, but merely that they are generalized statements of the conduct of matter. Natural science is nothing more than an orderly investigation into this orderly conduct of matter. One investigation leads to others. No sooner is one truth in nature recognized than it suggests others to be discovered and formulated.

The pervading principle of all nature is harmony. Holding to the truth of this statement, I desire in this paper to carry forward certain generally accepted

hypotheses in physics and chemistry to more ultimate conclusions than, so far as I know, have hitherto been attempted; and thereby I hope to suggest a theory of the cosmos.

Of necessity this discussion will be somewhat speculative; for it will have much to do with the ether, a medium in itself a mere speculation of science, as yet undemonstrated to any of our senses. Light reaches us from the far distant stars. We can conceive of no way whereby that light can come save as a vibration of some intervening medium, and science has named this hypothetical medium the "luminiferous ether." We are safe in admitting its existence as demonstrated by the phenomena of light, heat, and electricity, though we cannot weigh it, nor can we see it, feel, taste or smell it.

A complete theory of the cosmos must account for all phenomena observed. We may grant that heat and light are fully accounted for, but there are other outstanding phenomena as yet unexplained. Some of the unanswered questions are: What is electricity? What is gravity? What is life? The work of the scientific investigator is far from complete. The above questions need but to be mentioned to suggest that, glorious as has been the record of past discovery, the future will far outshine it in brilliancy.

Nature's primal law is harmony. There is endless variation, yet harmony in it all. There is no harper on themes like nature. She discovered that she could propagate a polyp by an egg; and she never forgot the process, even in the perpetuation of the highest of animals, and man must come into the world by the egg route. A simple protozoan cell can make its way in the world by appropriating from all that comes to it only that which is for its good, rejecting all else; and what more is the highest mammal than a great organized aggregate of vitalized, protozoan-like cells, each one of which does that very thing—appropriates from its environment the nutriment it needs, while it rejects all else? The laws of planets about the sun are the laws of satellites about the planets; and they are the same laws for the winds and streams and ocean currents about the earth—the laws of gravitation of bodies about their common center. Why may we not expect these laws to hold in the molecular world of physics and in the atomic world of chemistry? A stone is dropped into a quiet pool, and the laws of the circling waves have been formulated as they apply in the mass movements of fluids. These laws have been applied with success to the explanation of sound propagation in air and to the phenomena of light propagation in the ether. Some have ventured to extend the theory to electric propagation; and why not? Why not go a step further, and find a theory for gravity based on the same laws? Heat, light and electricity are regarded by some as correlated forces. Why not class gravity with them? They are all certainly capable of having their energies interchanged. We find the theory of vibrations good for explaining sound, heat, light, and some apply it to electricity. Why not extend it to the realm of gravity and chemism? The all-pervading harmony in nature certainly encourages us so to do.

In its efforts to unravel the mysteries of the material universe the human mind has ever run up against the hitherto unsurmountable barrier of gravitation. A stone thrown into the air falls to earth again—*why?* The wise have ever declared that it does so because the earth attracts it; and most people have been satisfied with the answer as a simple and complete solution of the problem. But that this was no explanation of the phenomenon was recognized as long ago as the time of Sir Isaac Newton. He himself declared, and we must admit the self-evident truth, that one object cannot act upon another at a distance save by some bond of union between the two. Between the falling stone and the earth

exists no elastic cord whereby the latter pulls the former to itself. How, then, is it that the stone falls to the earth? Why does the moon fall toward the earth? Why do the moon and earth together and all the other planets fall toward the sun? Why does the sun, with his retinue of planets and their satellites, move through space toward some other center? In short, we would ask: Why any of this motion of stars and comets, of suns and satellites? To say that they so move under the law of gravity does not tell us *why* they so move. Newton recognized the force of this; but even his great mind could leave us no plausible explanation. But the two centuries since his time have revealed many things unknown to the great master; and, though the explanation of the common experience of falling is apparently as much wanting now as then, yet perhaps we may collect a few hints in the various fields of science, and on them hinge a theory which may be of interest to contemplate, if not productive of better results.

The two great natural sciences are chemistry and physics; for on them hinge all others. The more subtle of the two, chemistry, has for its realm that of the atom; the other, the grosser, physics, deals with the molecule and molecular aggregates, masses. Now, who shall deny that possibly some day we may have a third grand science, more subtle still than either of the others. This third science is as yet unnamed, but its province is broadly hinted at already in the speculations of the other two. Its field shall be the ether; therefore, call it "etherics." True, physics is claiming the ether as a part of its domain in seeking to investigate and explain the phenomena of light and electricity. But is not this clearly a usurpation, inasmuch as light and electricity are admittedly extraneous to the molecule?

And again, chemistry is claiming a part of this field when it attempts to trace the genesis of the elements, as is implied in their grouping into families by the periodic system, as if they had a common progenitor. As yet we can go no farther in our explanations for the formation of the various chemical compounds than to say that they result because of the chemism that exists between the several elements constituting the compound; that is, the affinity that one element has for another. This third science will have for its province the capacity to step back of that affinity and explain *why* it is; why, for instance, oxygen has a stronger affinity for hydrogen than for any other element, and a weaker affinity for fluorin than for any other element; just as also it will tell us *why* a stone tossed in air falls to earth again.

The term "molecule" is a theoretical conception to account for the facts of physics; and it does so very successfully. The atom is a theoretical conception of the chemist, introduced to account for the facts of chemistry. He will tell you that the molecules of a few elements are made up of but a single atom each; while most elemental molecules contain two atoms, and others may contain three, four or six atoms; and a molecule of an organic compound may contain as many as a hundred or more atoms: yet he can never hope to perceive an individual atom by any of his senses, though he may weigh atoms relatively and speak of atomic masses confidently.

Thus we have the molecule for physics, and the atom for chemistry. Our third science, etherics, must also have its unit, and we shall call it the "protatom."

Though our name for this particle smaller than the atom is new, the conception of the existence of such small particles is as old as Prout's theory of the composite nature of atoms, and probably older. More recently, Lockyer's spectroscopic investigations of certain chemical elements point to similar conclusions; and Prof. J. J. Thompson, in a Royal Institute address on the cathode rays, de-

livered April 30, 1897, presented mathematical results indicating that the "particles carrying the electric charges" in those rays must be very much smaller than the hydrogen atom.

But before we speak further of the protatom and the role it is to play in our theory of the cosmos, let us examine the prevalent theory of the ether as set forth by modern physicists. By them the ether is defined as a continuous medium pervading all space, intermolecular and interatomic, as well as interstellar; perfectly elastic and exceedingly attenuated; without gravity; imponderable. There are here several qualities assigned to the ether which are contradictory and, for that reason, illogical. How can a substance be elastic and at the same time absolutely continuous? To be elastic it must yield to stress or pressure in the region where the strain is applied, and then, on the removal of the stress, it must return completely to its original position, if perfectly elastic. Now, if a space be already full of the ether as such, how is more of it to be conceived to be crowded into that space? "By making the ether more dense in that particular region," it may be said. But "density" is a relative term, and implies that a greater or less quantity of matter occupies a definite volume. The quality "density" cannot logically be predicated of a substance which is already supposed to *fill* all space. If a measured space is absolutely filled with a substance no more can be introduced, and none can be abstracted without leaving the space incompletely filled. Here, then, we find a plain contradiction of statement, when it is asserted of the ether that it is perfectly elastic and also that it occupies all space.

The ether is also said to be "imponderable." If that be the case, how can it have mass? How can it resist action and thereby produce reaction? That is: how can it propagate energy, or convey energy, or impart energy? That it does all this we know from the phenomena of light, electricity, and radiant heat. In a certain sense a mass may be so positioned that it will "weigh nothing," as would be the case of an object located between the earth and the moon at the place where the "attractive forces" of the planet and satellite exactly neutralize each other; but even in that unique position that object would not be imponderable in the sense in which that term is meant to be applied to the ether. Just as much force would be requisite to impart to a unit mass of that object a velocity of one centimeter in one second out there in space as would be necessary were it at the earth or were it located anywhere else in the universe. Balancing the forces at play on a mass does not render it imponderable. Were the mass imponderable, it could be put in motion at any velocity whatever without the application of force. This is impossible with any mass whatever; therefore the term "imponderable," in its true physical sense, cannot be applied to matter of any kind. Now, we know force is necessary to produce motion in the ether. The carbon filament in an incandescent lamp must be at least red-hot in order to establish those waves in the ether we call light. A dynamo must be run by a steam-engine or by some other power to induce those waves in the ether about conductors, which waves we call electricity, and the energy of which waves brought under control runs our street-cars and turns the night of our cities into day. There is every evidence that a dyne force would be necessary to impart to a gram mass of the ether a velocity of one centimeter in one second, as is the case with all other forms of matter. The ether is therefore ponderable, and a gram mass of it would be such quantity as a force of one dyne could bring to a velocity of one centimeter per second, if applied for that interval.

Let us have a better notion of the ether than this attempt at a conception of an imponderable yet forceful, exceedingly attenuated yet infinitely continuous, perfectly elastic yet incompressible, all-pervading, incomprehensible form of

matter so different from every other form that it is puzzling to know why those who are responsible for such theories of the ether ever thought of it as matter at all.

The ether is undoubtedly a form of matter; and as such it must present all the essential properties of matter: elasticity, impenetrability, inertia, mass, and work must be done to put it in motion. Let us get a conception of the ether which will admit of all these essential properties of matter, and which will eliminate the contradictions of the old theories. Let us think of the ether as made up of protatoms—particles which constitute the atoms of the tangible elements about us everywhere. Let us suppose these protatoms to be separated from each other by distances which are great as compared with their own diameters; and let us conceive of the spaces between these protatoms as absolutely void—nothing there at all. The conception of empty space is not beyond the human mind, as some have contended; for space is only pure extension, which may be occupied by matter or not, according to circumstances.

One more conception is necessary: that of motion. Our protatoms must be in motion. But whence the motion? is asked. As well ask: Whence the matter? Matter and motion of matter are coexistent. These are the two fundamental ideas of the material universe. Upon them is built the cosmos. Is matter eternal? so is the motion of matter. The approach of particle to particle, the recoil, the consequent approach to other particles, and recoil, are as eternal as the matter itself. Whence it is no science can tell, as no science can tell whence the matter with which it deals. Absolute rest, absolute absence of this approach and recession of particles and masses, would be as difficult of explanation did such a condition of affairs exist in nature.

Briefly, the conception of the ether which I desire to suggest is: that it is constituted of minute particles which I call protatoms; these protatoms may be of various sizes, but all are minute as compared with their mean distances apart in the otherwise void space; in this void space they move with a great range of velocities in every direction, and hence they are continually colliding and rebounding, with no diminution, however, of their sum total of energy; for what motion is lost to one protatom, owing to the angle of impact, may be found as imparted to the protatom struck, all being perfectly elastic.

Owing to their varying distances apart and to their variance in size and velocity, a tendency to grouping will arise, if indeed the existence of groups may not be considered as a primal condition. This will be a selective grouping, analogous to that seen in the case of concretions and other grosser aggregates, such as crystals, "pillow witches," hair balls, etc. Groups of like size and weight will show like properties. They will constitute the chemical atoms. This vibration of the ether protatoms will continue to play on the atomic aggregates, not as aggregates, but as they strike and rebound from the individual constituent protatoms of the atoms. Some of the free ether particles may even penetrate to some depth among the protatoms of the atoms before they strike a resisting particle, and thereafter may be a part of the atom, while others at the periphery of the atom will swing out into the free ether, and again become independent protatoms. Thus the atoms are not absolutely constant in their mass, and recent investigations on the atomic weights of some of the elements lend argument to this view. An average mass for the atom would be maintained, the losses under the action of the surrounding ether balancing the gain, as is the case of the formation of pillow witches in a pillow of feathers.*

The atomic aggregates which are comparatively near would shield each other

*See article on "Concretions," Kans. Acad. of Sci. Transactions, vol. XVI, pp. 44-46.

to a greater or less extent from ether impacts on their sides facing each other, and would thereby be *driven* together. Thus would arise the molecules, their sizes also being determined on the same principle as that which determined the sizes of the atoms. Atomic aggregates of like size and vibration associated together would constitute molecules of elements. But when atomic aggregates of unlike size and vibration are brought into proximity they may be driven together in greater numbers, and because of their very difference they may be held together with greater force. Thus very complex molecules may arise, as in organic compounds. Here, then, in the vibration of the protatoms of the ether we find an explanation of chemism.

But we shall find more. The molecules are under the same influence of protatomic vibration, and are driven together by their interior faces being shielded to some degree from impact, thus making a preponderance of impulse on the exterior; and we have aggregates of molecules resulting, ranging in size from those more than microscopically small to those we can handle, and others too large to handle. Thus we find cohesion and adhesion explained. But we have yet more. The masses in turn shield each other from the impacts of ether waves, and the blows are more numerous on their exterior faces than they are on their sides turned toward each other, and in consequence they are driven together, or at least toward each other. Herein we find an explanation of *gravity*. Remember, the impacts are not of protatoms moving immensely long distances; this is no "corpuscular" theory. The motion is a *wave* motion, and the masses are not struck as such; but the individual protatoms at the surface and to some depth have received the impacts, taken up the motion and imparted it to the next series of protatoms toward the interior, then rebound. Thus the whole body is influenced to move by reason of the motion imparted to its constituent protatoms.

Therefore every material body, however small or great, tends to move towards every other body, being *driven* to do so with a tendency directly proportional to their masses, and inversely as the square of their distances apart. To say that they attract each other is meaningless, but to say that they are driven together under the force of *ether vibrations* may be an explanation.

But how is it possible that the external pressures due to ethereal impacts on the two masses are greater than the pressures due to the impacts against the interior faces?

To explain how this may be we will recall a very interesting experiment in the physics of sound, as follows: If two tuning-forks are suspended near to each other and are made to vibrate they will approach each other. Various explanations for this and similar phenomena have been given, the usual one being that they are due to air currents established. The explanation I would offer is: The sound waves of condensed and rarefied air between the two forks meet and neutralize each other to a greater or less extent by crests of condensation meeting troughs of rarefaction, while the pressure of the air on the more remote sides of the forks remains practically the same. Thus the forks are driven together by the excess of pressure from the outer sides.

Now, let us apply this to the ether. According to our theory, the protatoms are in eternal motion, meeting and rebounding continually. For the most part, this motion in the outer ether is chaotic; that is, it lacks rhythm. But even in such a chaotic ether there must exist regions where the protatoms are more numerous and closer together than in other regions. The irregular vibrations striking into such aggregates will be more or less absorbed; that is, the motion will become, to a great extent, a *resultant* motion, belonging to the aggregate as

such, rather than to the protatoms as individuals. Thereafter it will be transmitted and emitted by the aggregate as a regular wave. Of such nature are light waves and all other forms of radiation—they are all induced in the ether by the vibration of aggregates; that is, for the most part, by vibration of atoms and molecules. The motion is no longer one of individual impulse, as it was in the outer chaotic ether, but is now an organized wave. Should there be but one such aggregate, the organized wave would again become broken up by the ultimate preponderance of individual impacts as it moves on into the chaotic ether, and the single aggregate we have been considering would not be shifted in space. But suppose another aggregation of protatoms in the vicinity. This is also receiving chaotic impacts from all sides, and sending out organized waves; but on the face turned toward the neighboring aggregate it is also receiving wave impacts. The waves thus propagated between these neighboring aggregates will necessarily neutralize each other to some extent, as in the case of tuning-forks vibrating in air, and the result is the aggregates are *driven* toward each other. They meet and rebound, or circle about each other, according to their masses, previous motions, and resultant directions taken. They are a "molecule." The same principles hold good for larger aggregates and aggregations of aggregates. *This is gravity.* It is more. It is a persisting principle throughout the cosmos. It is the cause of cohesion, of adhesion, of chemism. Electricity, light, magnetism, are due to more orderly waves. They are the ones we can in a measure handle.

If we can in a measure control these waves between bodies, we can to the extent of that control annul the force of gravity. What more is magnetism than the exercise of such control? A magnet will prevent a bit of iron from falling; that is, the gravity waves between the earth and the bit of iron fall far short of neutralizing each other to the extent that other waves between the magnet and the piece of iron are neutralized; and the latter two are driven together with considerable force.

Again, gravity action is overcome by "static electric charges." What is an "electrified" body? It is one whose atoms and protatoms have been thrown into such a state of vibration that a preponderance of the ether impacts they suffer are harmonized, and the energy of the impacts is given out as that of definite waves in the ether. The waves from a "positively" charged body neutralize those from a "negatively" charged body to an unusually marked degree, and the two are driven together with a very perceptible force. They touch and are "discharged." But what is a "discharge"? It is simply a breaking up of the previously induced condition of regularity of vibration of atoms and protatoms which was called "charging." But how is a body charged? Break a lump of sugar, and the two halves become electrified. The atoms are set into regular vibration by the rupture, just as a tuning-fork is set into vibration by suddenly releasing its prongs from pressure. All frictional charges are due to a sudden separation of particles. But an electric charge may be obtained by induction; so can a tuning-fork be set to vibrating by the sympathetic vibration of another fork of like pitch. Indeed, all forms of electrification, current as well as static, may be said to inhere in vibrations established either by sudden separation of particles, whether by mechanical friction or by chemical action, or the vibrations are established by induction.

Furthermore, we may know now what becomes of energy radiated "into space." Of all the heat and light radiated from the sun, only a very small part falls upon the members of the solar system, and a still smaller portion strikes the members of other systems. The sun is but a point of light as viewed from the other stars.

What of the vast, apparently wasted, energy that must go on, and on, and on, through space? Is it lost? I answer, No. It abides; it remains in the ether; not as light, not as heat radiation, not as electricity, ultimately, but as *gravity*, reduced to the primal condition of energy; chaotic, protatomic vibration of the ether. From this primal condition it may again be reorganized into regular waves of definite length, and therefore of definite name, as light, or heat radiation, or electricity, by traversing atomic and molecular aggregates. Thus do we round out one more cycle in this great universe of cycles.

An astronomical problem of interest is the question of friction in the outer ether. Why are not the planets and comets retarded in their courses by friction with the ether? Even the tails of comets are not slowed up in their passage about the sun. Instead of these bodies being retarded by the ether, our theory discovers in the ether their very propelling medium. It is the ether impacts which are driving the comets toward the sun and the sun toward the comets by the organization of waves between them, as between all other bodies, as we have endeavored to show.

By our theory of the cosmos, electricity and gravity are considered as forms of energy inhering in the ether vibrations. By this view they become correlated with light and radiant heat. Thus we avoid the old, cumbrous and inexplicable conception of electricity, which regards it to be a form of fluid matter, imponderable, incompressible, entangled as it were in the ether. We affirm of such a notion of the "electric matter" what we have asserted of a like conception of the ether: that it is illogical, and, therefore, impossible.

Gravity is usually spoken of loosely as a force, and not as a form of energy. Force is a tendency to produce or alter motion in matter. The force may be exerted and measured without the motion actually resulting, because it may be balanced by an equal counteracting tendency. We have found by our theory that gravity is inherent in the moving protatoms of the ether. It is there by virtue of that motion, and is therefore a form of energy, just as heat is present in a material mass by reason of the vibration of its molecules, and is therefore a form of energy. Motion of matter is essential to all forms of energy. Without motion the idea of energy is inconceivable.

Briefly stated, the conception of the cosmos which I wish to suggest is: The material universe is made up of matter in eternal motion. All is matter and motion of matter. The masses, as we know them about us, large and small, are made up of molecules in motion. These molecules may meet and rebound or swing about each other in their movements, but they are never in permanent contact. So small are they that their existence cannot be detected as individuals by any of our senses, yet their existence is established by the principles of physics. The molecules in turn are conceived to be made up of atoms, to satisfy the demands of chemistry. And now, I hold that the atoms must be subdivided into protatoms, to conform to the demands of etherics; that in the motion of these various aggregates of matter inheres the energy of the universe—as energy of mass motion in the movements of sensible masses; as heat in the motion of molecules; as chemism in the motion of atoms; and as light, radiant heat, electricity, magnetism, gravity, in the motion of the protatoms of the ether; that the ether itself is made up of protatoms, as yet unassembled into atoms, more or less evenly distributed, with absolutely void spaces between them; that across these spaces the protatoms move unhindered until they collide with other moving protatoms, when they rebound with undiminished energy because of their perfect elasticity; that the energy of this ultimate individual protatomic vibration is gravity; that this protatomic vibration becomes transformed in the atomic, molecular, and mass

aggregates into the resultant energy of organized waves; that the waves which are emitted on the sides of bodies facing each other are more or less neutralized, thus allowing of a greater pressure on the outer sides, and thereby causing the bodies to be driven together. Finally, the theory presented discovers a complete cycle in the transformation of energy. Hitherto the energy dissipated into space has found no explanation for its conservation and return. The theory presented herein recovers that energy in gravity, ready to be again transformed in endless recurrent changes.

A BRIEF OUTLINE OF ECOLOGY.

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An address delivered before the Academy, at Topeka, December 29, 1900.

I have been requested by the Academy to present a paper upon the subject of "Ecology." On account of numerous other duties, I have decided to make this subject the title of the address expected of me this year as retiring president.

The word "ecology" is of recent origin. The word seems to have been first used in 1891, by Strasburger, a German botanist. He says, in his discussion of the subject: "Anpassungslehre oder Œcologie, falschlich jetzt als Biologie bezeichnet, da auch doch Biologie uberhaupt die Lehre von den lebenden Wesen ist." In 1893 the Madison congress considered, among other matters, the terminology of plant physiology. It fell to me, as a member of the committee appointed to formulate suggestions, to present our conclusions upon the subject of ecology. It was recommended that the term "ecology" be used for that part of plant physiology which deals with the adaptive processes of plants, and that it be spelled with an "e" instead of "œ." This recommendation was adopted, and the word has since come into general use. Although the word is of recent origin, the subject itself has received attention for a much longer period. In Germany, it has been known under the name of "biologie," and, for want of a better term, the corresponding English word "biology" has been used in this country. But biology, properly, refers to the science of life, and includes the two branches, zoölogy and botany. Hence this second use of the word produces confusion.

It is difficult to accurately define ecology, as it cannot be easily limited; but, as generally accepted, it includes all that part of physiology in general which deals with the effect of environment upon the plant. Physiology, proper, deals with the action of physical and chemical forces within the plant. A study of the chemical changes connected with nutrition, or the physical forces involved in water absorption, is in the domain of physiology. A study of the methods by which a plant adapts itself to changes in the amount of water or light, or the different soil conditions, is in the domain of ecology. It will be seen that ecology deals with organs and physiology with the cell. But in one-celled organisms or even in little differentiated multicellular organisms this difference becomes reduced to zero. While it is convenient to segregate certain vital phenomena under a separate name, it must not be understood that these phenomena are not brought about by the same forces that are considered in physiology. But physiology deals with its phenomena as identical with phenomena in the physical world, and is constantly trying to reduce these phenomena to their lowest terms; as it were, to coordinate them with similar phenomena observed in the laboratory. To the physiologist the cell forming the root hair is an example of osmosis, and its action can be successfully reproduced in the laboratory. The living protoplasmic membrane is the osmotic membrane; the soil water, a weak solution of

minerals, is on one side and the more concentrated cell sap is on the other. A current is set up from the soil water to the cell sap, and the cell thus absorbs water containing the necessary mineral food. This process, then, is not peculiar to living organisms. In a like manner, the chemist looks upon the synthesis of carbohydrates in the plant as a purely chemical process. While this process has not been reproduced in all its steps by the chemist, yet he, with the botanist, looks upon this as a process which can be carried on independently of the plant.

Now let us examine one or two cases of ecological phenomena. Certain leaves when exposed to too much light twist on their petioles so as to bring the edge of the leaf in the direction of the light; that is, the leaf lies in the plane of the incident rays. They thus escape the injurious effects of the light, and, what is more important, at the same time escape the accompanying heat rays, and thus reduce the evaporation from the leaf surface. This phenomenon, known as "paraheliotropism," is common in plants of the dry regions. The organ in this case responds to a stimulus, and responds in such a way as to protect itself against injury. A plant under these circumstances is said to adapt itself to its environment. A phenomenon of this kind is more distinctly vital. I do not wish to be interpreted as separating vital phenomena as fundamentally different from nonvital. From a philosophical standpoint, I cannot admit that they are; but on account of the extreme complexity of the combinations they are more conveniently studied as combinations. No doubt the phenomena of paraheliotropism is capable of analysis and will be found to be a combination of so-called single phenomena. But it is really this adaptibility or mobility in a plant which distinguishes a living thing from a piece of apparatus.

It is not my intention to discuss the fundamental relations of ecology to physics and chemistry, nor to propound a theory of life. Instead I wish to give a brief outline of the subject in its present status. I interpret this as the wish of the Academy when the subject was assigned to me.

During the Linnæan period, and for some time afterward, plants were studied only to be classified. As you all know, the nature philosophy of that day looked upon species as fixed; hence, the chief care of the botanist was to so describe a plant that it could with certainty be distributed into its proper pigeonhole. The descriptions in Linnæus's "Species Plantarum" are models of clearness. The pigeonholes are well distinguished. But, alas! the plants so often fail to conform to the descriptions. When considering two closely allied species Linnæus apparently threw into the waste-basket all intermediate forms. Botanists in general seem not to have taken much interest in plants as living organisms. This tendency persists more or less to the present day, but is fast disappearing. Systematic botany holds a prominent position in the various branches of the botanical science; but its study is modified to suit the accepted philosophy of development.

One of the earliest to record systematic observations in ecology was Sprengel, who in 1793 published a little book upon "The Secret of Nature in the Form and Fertilization of Flowers Discovered." He laid the foundation of the theory of honey containing flowers, viz.: that the flower secretes nectar to attract insects, sometimes a single species; that the flower is of such a shape that the insect in getting the nectar is compelled to transfer, unconsciously of course, the pollen from the anthers to the stigma. It is a curious fact, however, that Sprengel did not recognize the real reason for all this: that the insects were utilized by the plant to transfer pollen from one plant to another because cross-fertilization is better for the plant than self-fertilization. The result was that Sprengel's ex-

cellent observations were relegated to obscurity by the upper crust of botanists—the systematists who did not care to waste their time on such amateur work.

While ecological observations are scattered here and there through later botanical writings, they lacked coherence, and this branch was constantly handicapped by the theory of the fixity of species. It remained for Charles Darwin to bring order out of chaos and give us a working theory of development. His investigations may be said to have laid the foundation of ecology. It is needless to dwell upon the theory of the Darwinian school, but ecology owes its impetus to the recognition of the plasticity of species. The study of adaptability has been so active and the mass of facts accumulated has been so great that it was recognized as a distinct branch of botanical science, first under the name of biology and later under the name of ecology. Let us now take a look at a brief classification of the subjects included. It will be seen at once that ecology is a study of life relations—the relations of the plant to its environment. The factors which influence the plant from without are known as ecological factors, and may be arranged for the most part in the following groups:

WATER.	AIR.	ANIMALS.
HEAT.	SOIL.	OTHER PLANTS.
LIGHT.		

The fact that a plant thrives where it is shows that it is adapted to the conditions, and that an equilibrium has been established between the plant and the factors normally surrounding or affecting it.

WATER.—Water is a vital necessity. The variation in the water-supply causes corresponding variations in the structure. In submerged plants the water with the containing mineral matter is absorbed directly. Hence there is no transpiration current, and the roots have no absorptive function. Roots when present are fastening organs. If the leaves are floating or emerged there is set up a transpiration current which must be supplied from beneath by the absorptive action of the roots. In all land plants a transpiration current is necessary to supply the mineral matter from the soil. It is not often that the soil conditions and air conditions are so evenly balanced that the plant is free to take up and evaporate all the water it needs for the most rapid growth. In some cases, on account of the saturated atmosphere, there is danger from a stagnated transpiration current, and the plant endeavors in various ways to aid evaporation. Experiments have shown that an individual plant can be profoundly modified by a change in the water relation. A normally xerophytic plant with rosette foliage can be made to stretch out its axis, to broaden its leaves, and otherwise take on the structure of a hygrophyte. To indicate the nature of the problems presented I will suggest a few adaptations, some proved by experiment, others still hypothetical. In the rain forests of the tropics the leaves are often provided with long points and converging veins to lead off the water easily. Mottled leaves in which irregular areas lack chlorophyll increase the evaporating surface without increasing that engaged in photosynthesis. The presence of the red coloring matter on the under surface of floating leaves may be for the purpose of converting the waste light into heat, thus slightly raising the temperature of the leaf and enabling it to evaporate, when otherwise the air would be saturated and prevent evaporation. Glands which excrete liquid water are common. On the other hand, in dry regions the plant is obliged to prevent evaporation as much as possible, without entirely suppressing the transpiration current. There are numerous and curious methods by which plants protect themselves from drought.

HEAT.—Plants are rarely injured by the high temperature to which they are subject in nature, provided the water-supply is not reduced. But, except in the

tropics, they are likely to be subjected to low temperature, to which they must become adapted in order to live. No plant can vegetate at a temperature below freezing, but by proper adaptation many plants can endure an indefinitely low temperature in the resting stage. In high latitudes it becomes a question of ability to endure the long winter. Plants have been found as far north as soil conditions have permitted their growth. At high altitudes, however, vegetation is limited by the lack of a growing season. The temperature may remain throughout the year below the point at which growth is possible. Under this head, then, is the study of the methods of resisting injury from low temperature.

LIGHT.—Too intense light is injurious, while with too little light the process of photosynthesis cannot be carried on. By assuming the profile position, either temporarily, as in motile leaves, or permanently, as in compass-plants, with vertical leaves, injury from too intense light can be avoided. Others must exert themselves to obtain the maximum amount of light. Some plants bring the leaves into the maximum light position by heliotropic movements. Submerged water-plants and the shade plants of dense forests are obliged to adapt themselves to the minimum amount of light for growth.

AIR.—Aside from the indirect effect upon transpiration, the air relations of plants may be divided into about three groups: (1) The supply of oxygen for the purpose of respiration, which is necessary to all active cells. Interesting adaptations are found in swamp plants for leading air down to the roots: aerating tissues, air canals, cypress knees, etc. (2) The direct mechanical effect of wind upon the plant body. (3) The methods by which plants utilize air-currents for the dispersal of seeds and pollen.

SOIL.—Soil relations may be chemical or physical, the latter being by far the most important. The elements necessary for plant growth are usually present in cultivated soil in sufficient amount, and, usually, there is nothing in the soil which is of direct injury. The physical condition of the soil is chiefly concerned with the water relation. When the soil contains a large amount of soluble salts plants have difficulty in absorbing sufficient water; and when the soil water is as concentrated as the cell sap, plants cannot exist. Such conditions obtain in salt marshes, alkali plains, etc. And the plants are of a pronounced xerophytic type, from the necessity of reducing transpiration to suit water-supply.

ANIMALS.—Animals use plants for food, and they inflict injury by tramping upon them. Hence, protective devices in the shape of thorns and prickles, or a bitter or irritating sap, and the rosette habit. Insects aid in the pollination of flowers; a study of which is an important branch of ecology. Animals aid in the dispersal of seeds, by accidentally carrying those which have devices for attachment, or by eating the fruits, in which the large seeds are thrown away and the small ones escape digestion. Special relations which are extremely interesting occur between ants and plants. Certain leaf-cutting species of ants cultivate a kind of fungus in their underground nests. The leaves are gathered to furnish a substratum for the fungus, which, in its turn, yields a peculiar fructification upon which the ants feed. Other species, enemies to the preceding, are retained as guards by several kinds of plants, which thus escape denudation. These plants furnish especially formed homes, and often also food for their protectors. The homes and special-food bodies appear to have no other function than that of inducing the guards to take up their abode there and recompensing them for their trouble.

OTHER PLANTS.—Every individual, from the time it is cast loose from the mother plant as a seed, must struggle against the various factors mentioned, but

its severest battles are those against other plants, which compete with it for soil, light and water. And the competition increases with the closeness of the genetic relationship. There is always an appreciable probability that a plant may find a niche in nature where it can avoid competition from other species, but it is a very rare exception when a plant can escape competition from other individuals of the same species.

So far we have taken a cursory view of the ecological factors. We will now turn to another branch of ecology, which may be called ecological plant geography. It might be called the distribution of plant societies.

Plants may live together and bear to each other several kinds of relationship. The competition for light has developed a physiological class of plants called lianas, or climbers, which use other plants as their support, and hence escape the necessity of forming a self-supporting trunk. Epiphytes are plants which use others as a substratum upon which to grow, but are not parasitic. They are usually xerophytic in their structure, and have developed many curious contrivances for catching and holding rain-water. Saprophytes derive their organic food, more or less elaborated, from the partially decomposed vegetable debris. Parasites absorb their food, or a part of it, directly from the living cells of their host. In certain cases, as in lichens, there is the relation of master and slave (helotism). Certain fungi derive their nourishment from simple forms of algæ, but nevertheless protect them, the whole organism (lichen) having a definite structure, depending upon the species of fungus and alga involved. The most common relation, however, is that in which different species of plants compete with each other for existence under the same conditions. This relation has received the name "commensalism." A study of these relations has given rise to the branch of ecology known as ecological plant geography. The plants which live under similar conditions have a definite physiognomy, and are called a plant society, or rather, more commonly, a formation. Where the conditions have remained practically the same for a period sufficient for an equilibrium to be established, the species have become adapted to the conditions, including the tendency of the individuals to encroach upon each other. Thus, a plant society is defined as being those individuals which exist together under a given set of conditions. There have been attempts to classify societies into four large groups: Hydrophytes, those living in water or where the soil is saturated with water; xerophytes, those living in more or less arid situations and where the plants must resist evaporation; mesophytes, where the conditions are medium so far as water-supply is concerned; halophytes, where there is an excess of salts in the soil. The division is, however, not satisfactory. Swamp plants would be classed among the hydrophytes; yet they possess undoubted xerophytic characters, such as vertical leaves, reduced surface, thick epidermis, etc. Swamp plants must resist evaporation at times, when, on account of the cold, wet soil, the roots are not active enough to supply the transpiration current. Schimper, a recent writer on this subject, attempts to divide plants into hygrophytes, those on which the transpiration current must be aided; xerophytes, in which the transpiration current must be hindered; and tropophytes, in which there is an alternation of these two sets of conditions. Like all classifications, it has holes in it. It is more satisfactory to classify on the basis of adaptations, and recognize certain ones as xerophytic and others as hydrophytic. Many of our deciduous trees may be classed among the mesophytes, yet they have the very prominent xerophytic character of dropping their foliage on the approach of winter. In another paper I have discussed the ecological plant geography of Kansas. The xerophytic flora predominates, the chief societies being prairie flora, flora of the sand-hills,

and flora of stony hills. The hydrophytic societies occur in and near our water-courses, ponds, sloughs, marshes, and springs. The mesophytic societies are confined to the border-land between the hydrophytes and xerophytes, and more especially in the shade of the lowland woods. The halophytes are found in the salt marshes which occur through the interior of the state.

Although, while the conditions remain unchanged, the societies remain in an equilibrium, there is, nevertheless, what might be termed a conflict of societies going on everywhere. As soon as the conditions change, even slightly, one society will gain an advantage over its neighbors. There seems to be little doubt that the forest societies are gradually encroaching on the plains. It must not be inferred that every species is found where are conditions best suited for its development. It is, rather, that each species is found where it can best compete with others able to endure the same conditions. For example, in Kansas the red cedar is found on barren limestone cliffs, and presents a gnarled and more or less stunted aspect. Yet, under favorable conditions—that is, ordinary rich soil—it produces a vigorous and symmetrical body. The same is true of the bald cypress of our Southern states. It is found native in swamps, and usually is flat topped and stunted in its growth, with a much less vigorous aspect than specimens cultivated in moderately dry soil. It would appear that they have been unable to compete in those localities where they could thrive best, but have been forced to take refuge in the stony hills, in the one case, and the swamps in the other, where they can maintain themselves against their competitors. So we see that there is a constant struggle between individuals in a society, and between societies in a given area or region.

Ecology also includes the wider class of distribution ordinarily called the geographical distribution of plants; that is, the distribution of plants on the earth's surface into zones, regions, and areas. The division into zones is based on climatic conditions. There are four zones: tropical, temperate, arctic, and mountain. The regions are subdivisions of these zones of sufficient extent to eliminate the effect of local conditions. As examples, may be mentioned the great plains and the Arizona-Mexico desert region of North America, the steppes of Russia, and the pampas of South America. This study includes not only the actual distribution of plants upon the earth's surface, but also the causes which lead up to it, in so far as they are concerned with adaptation. Thus, we have the difficult problem of the origin and relations of the flora of a particular region. The conditions have not always been as they are now; but, under the influence of those mighty forces which have fashioned our continents, islands, mountains, and lakes, an indefinite number of changes have taken place in the relations and composition of the plant societies. Vast forests once flourished where is now a wide expanse of prairie. Palms inhabited the polar circle and arctic plants were spread broadcast over the temperate regions. Floral areas have had their rise and fall. First one species is dominant, then another. You are all familiar with the distribution of our arctic plants: how, in preglacial times, a more or less tropical flora surrounded the pole; how the oncoming cold drove all vegetation southward; how a modified vegetation followed the retreating glaciers, but left arctic representatives stranded on the high mountain tops of the whole northern hemisphere; how Greenland is so remarkably poor in species compared with other lands in the same latitude, because most of its flora was driven southward into the ocean; how the flora of eastern United States resembles more closely that of Japan and eastern Asia than it does that of California, because a similar flora found similar conditions in these two

regions and could successfully compete; but that portion which was driven down the western coast of North America came in contact with a flora better suited to the conditions, and so was exterminated, with exception of such relics of the past as the grand sequoias, which, however, cannot long survive. I might go on indefinitely with a tiresome enumeration of facts, but I think I have given enough to indicate, in a general way, the scope of ecology.

II. CHEMISTRY AND PHYSICS.

EXPERIMENTS ON THE RELATIVE HEATING POWER OF COAL AND ILLUMINATING GAS.

BY E. H. S. BAILEY, UNIVERSITY OF KANSAS, LAWRENCE.

Read before the Academy December 29, 1899.

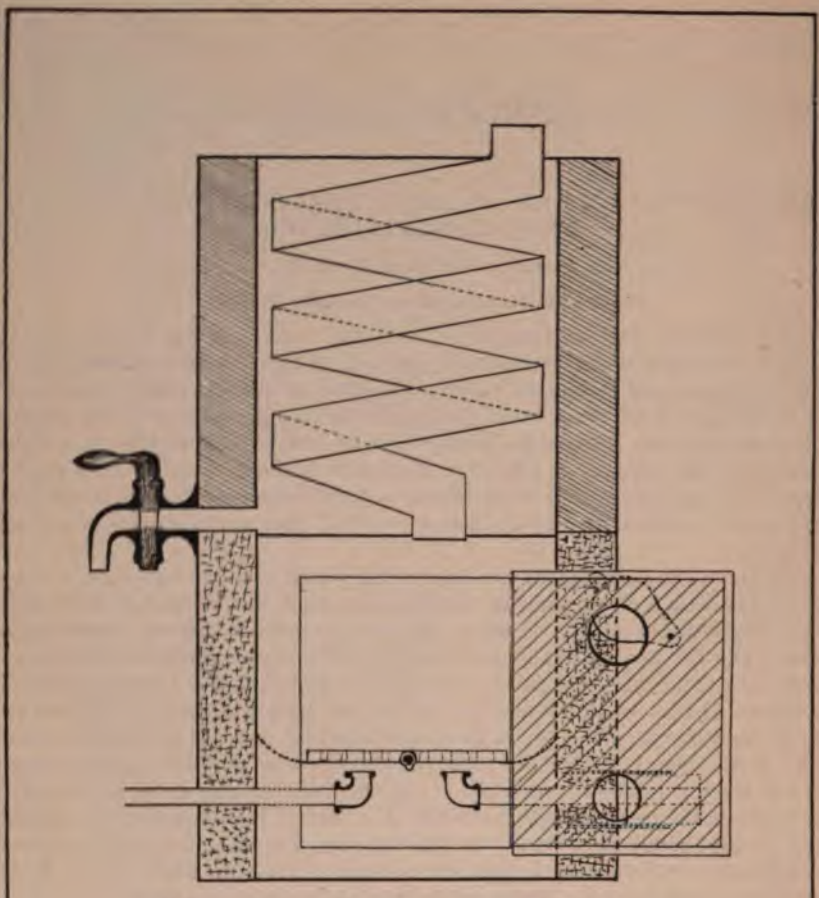
The problem that was brought to my notice some time ago was to find the relative fuel value of coal and natural gas, and, by this means, to determine how much per thousand should be paid for the latter so that the cost of fuel should be the same as if coal was used. Although we have the analysis of the natural gas as found in the Kansas gas fields,* and the composition of the coals of the state,† yet all attempts to arrive at the relative value of the two fuels from a theoretical standpoint were unsatisfactory, for the question was a practical one, and could be solved only by the use of a method that would imitate actual experience.

At first a crude apparatus was designed in which a weighed amount of water was boiled with a given quantity of fuel of each kind, but the loss of heat was so great that it was deemed advisable to construct an apparatus especially for the purpose. The furnace, as finally designed and used, is represented on next page. It consists of a cylinder of galvanized iron two feet high and fourteen inches in diameter. Inside of this is another cylinder ten inches in diameter and the annular space between the two is filled with charcoal, sawdust, or asbestos packing. Both these cylinders are soldered onto the base and onto the connecting ring at the top. A bottom is soldered into the inner cylinder eleven and one-half inches from the base. Inside the vessel thus formed is a one-and-three-fourths-inch tin pipe coiled three times, the upper end opening above the top of the vessel and the lower end passing through the bottom. This is the flue to carry off the products of combustion. Below the bottom of the kettle is a small grate which may be removed and its place supplied by the burner of a gas stove. There is a door lined with asbestos on one side of the lower part of the furnace. Just below the grate are two one-fourth-inch iron pipes terminating on the inside, with elbows turned upwards, and passing entirely through the apparatus to the outside. There is also a pipe leading from the bottom of the inside vessel closed by a spigot on the outside, so that the water may be quickly withdrawn from the inner vessel. A thermometer hangs in the water.

The apparatus is used as follows: The inner vessel is filled with water, and is then heated to boiling by means of the gas-burner; this water is quickly drawn out by the spigot and weighed on a moderately accurate balance; with the vessel in which it is contained it weighs about twenty-four pounds. The water is immediately, while still hot, returned to the boiler, the gas is relighted and the amount of gas consumed is carefully measured by a meter that reads to hundredths of cubic feet. The gas is allowed to burn for an hour or more, and then the water is quickly drawn off and weighed. The difference gives the loss by evaporation, which is calculated per cubic foot of gas.

In order to determine the heating power of the coal, the vessel is again filled

*Kan. Univ. Quar., vol. IV, pp. 1-14. †Transactions Kans. Acad. of Sci., vol. XI, pp. 46.



Apparatus for Testing Relative Heating Power of Illuminating Gas and Coal.

and the water taken out and weighed when boiling hot. A weighed amount of coal is put on the grate and quickly ignited, and its burning is accelerated by the use of a foot-blower attached to the two pipes coming to the outside of the apparatus, as previously mentioned. The products of combustion are carried up through the one-and-three fourths-inch pipe, which, in their passage, heat the water. Of course there is considerable smoke, and this is carried off by a two-and-one-half-inch pipe which fits over the smaller one. When the coal is nearly consumed that which remains is raked out and weighed, the water is drawn off and weighed, and the calculation is made with reference to the coal consumed.

While it is admitted that the apparatus is liable to some errors, yet it is devised with the object of imitating, as well as possible, the natural conditions which hold in the consumption of fuel under a boiler. The tests are comparative; and in neither case is all the heat utilized.

Some of the results obtained were as follows:

One cubic foot of gas will evaporate	*a*	0.45	lb. of water.
	a	0.46	"
	b	0.36	"
	c	0.39	"
	d	0 43	"
	e	0.36	"

These tests were taken on different days, when there was a different degree of humidity in the air, and when the temperature of the room was different. It was noticed also that the rate at which the gas burned had a decided influence on the economy of the operation. A rate of from six to twelve feet per hour was used, but the medium between these was probably most efficient. The amounts of water evaporated by the coal were as follows:

One pound of coal will evaporate	*a*	5.9	lbs. of water.
	b	3.9	"
	c	4.06	"
	d	4.5	"
	e	3.87	"

The only satisfactory method of using the apparatus is to test it first by the use of gas, and then under the same atmospheric conditions to test it with the coal. Hence, although the above tests seem to differ greatly, they do not differ so much when taken in connection with the corresponding gas test, made at the same time.

From the above tests, as we have ascertained the amount of water that one cubic foot of gas will evaporate and the amount of water that one pound of coal will evaporate, it is not difficult to calculate the value of one ton of coal in terms of gas. The results are as follows:

One ton of coal is equivalent to	*a*	23,000	cubic feet gas.
	b	21,600	"
	c	20,800	"
	d	20,900	"
	e	21,500	"
Average		21,500	

The experiments above noted were made with the ordinary illuminating gas. This gas, delivered to the consumers of the city of Lawrence, Kan., on December 6, 1894, had at that time the following composition:

Carbon dioxid (CO_2)	1.22
Olefiant gas and similar hydrocarbons	5.30
Oxygen (O)	.22
Carbon monoxid (CO)	7.50
Marsh-gas, methan (CH_4)	38.11
Hydrogen (H)	47.65
Total	100.00

The composition of the natural gas of the state may be fairly well shown by the analysis of a sample from the Neodesha fields:*

Carbon dioxid (CO_2)	1.00
Olefiant gas and similar hydrocarbons	.22
Oxygen (O)	.65
Carbon monoxid (CO)	.50
Marsh-gas, methan (CH_4)	90.56
Hydrogen (H)	0.00
Nitrogen (N)	7.07
Total	100.00

*Kan. Univ. Quar., vol. IV, pp. 1-14.

Comparing these two gases, it is evident that the illuminating gas used has a greater heating power than the natural gas, for in the illuminating gas there is 47.65 per cent. of hydrogen, and the heat units yielded by hydrogen are 34.462; while the chief constituent of the natural gas is marsh-gas (CH_4), which yields only 13.063 heat units, and this is practically the only heat-producing substance in the natural gas, all other gases being present in such small quantities.

In the tests upon coals, the first four were made upon Leavenworth coal, and the last two on Cañon City coal. It is evident that the process is not suited to determine the relative heating value of different samples of coal, and, indeed, that is not the intention.

If the average result obtained is taken, namely, that one ton of coal is equivalent in heating power to 21,500 cubic feet of gas, then, with Leavenworth coal at $2.50 per ton, gas would have to be sold at about twelve cents per thousand to be the equivalent in cost of the coal. Of course, as the coal increases in price, the cost of gas may also be raised proportionately. There is no doubt that the natural-gas producers in some of our districts could afford to furnish gas at this figure, but in others the price would be too low.

In the consideration of the relative heating power of the two fuels, no account is taken of the extreme convenience, wholesomeness and cleanliness of gas, nor of the fact that it can be lighted at any time when it is needed, and as soon as the work is done it can be extinguished. For convenience, then, there is nothing to equal gas; but this fuel must be sold at an extremely low price to compete economically with coal.

Lawrence, December 26, 1899.

ON THE EFFECT OF OXYGEN UPON ANIMAL LIFE.

BY J. T. WILLARD AND A. T. KINSLEY, EXPERIMENT STATION, MANHATTAN.

Read before the Academy, at Topeka, December 28, 1900.

The general view of those who think of it at all is that an atmosphere of pure oxygen would be most deleterious to animal life. That this view is not confined to the unscientific may be readily shown by reference to various authors. The following may be cited as typical:

J. F. W. Johnston, in his "Chemistry of Common Life," published in 1869, says: "Animals breathe oxygen with an increase of pleasure; but it excites them, quickens their circulation, throws them into a state of fever, and finally kills them by an excess of excitement. They live too rapidly in pure oxygen gas, and burn away in it like the fast-flaring candle. Did the atmosphere consist of oxygen only, the lives of animals would be of most brief duration."

C. W. Kimmins, in his "Chemistry of Life and Health," 1892, says: "The removal of nitrogen from the atmosphere would be as fatal as the removal of oxygen; and universal death would be accompanied by universal conflagration."

Gray says: "The Creator has adapted the atmosphere to the support of life, as anything which destroys the relation thus established renders it deleterious to the animal constitution."

Dr. B. W. Richardson seems to be one of the few who have made experiments as well as statements. He confined mice in a chamber of oxygen. In the first experiment, conducted at a temperature of fifty-five degrees F., the mouse was dead at the end of four hours. The second experiment was conducted at a temperature of seventy-five degrees F., and the mouse was taken out in deep sleep

at the end of the ninth hour. In a third experiment, at sixty-five degrees F., the mouse was dead in four hours and forty-two minutes.

T. H. Dinsmore, jr., also experimented, using mice and kittens confined in large jars of oxygen. They were left in thirty to sixty minutes in general, but one kitten that was left in an hour and a half was removed in an unconscious state. This result was attributed to the accumulation of carbon dioxide. In the other cases no result was observed except an increase in the rate of respiration. After remaining in the oxygen an hour they were apparently as well as when first placed in the gas. These experiments can hardly be regarded as conclusive because of their short duration.

It should be mentioned further, before taking up a description of our own work, that one or two writers do state that animals may live in oxygen without inconvenience; but no experimental evidence is adduced on the point.

In our investigations we designed to experiment with a variety of animals, introducing them gradually into the atmosphere of oxygen, and retaining them under its influence for a somewhat prolonged period. We also deemed it wise to avoid the use of animals which, like mice, cannot endure much handling even under normal conditions. The animals were enclosed in a tight wooden box one cubic foot in capacity. It had a glass front. An opening at the top for the introduction of the animals was closed by means of a tin lid which rested in a a groove into which melted wax was poured. Openings fitted with glass tubes, which could be closed with rubber stoppers, communicated with tin dishes for food and water. Two other openings served to admit oxygen at one of the lower corners, and for its exit at the upper diagonally opposite one. The box also contained a flat tin dish, partially filled with a solution of sodium hydroxide, the dish being covered with wire screen. A layer of sawdust was placed in the bottom of the box. The oxygen used was prepared from a mixture of potassium chlorate and manganese dioxide, and was stored for at least a week before use in cylinders. The oxygen was delivered from the cylinders, passing through a wash-bottle containing water, which served as an index to the rate of supply, and thence into the respiration chamber.

The storage of the gas was for the purpose of affording ample time for the absorption of all solids projected over in its preparation, and the gas as delivered was perfectly clear, though doubtless not chemically pure. A steady, though not very rapid, current of the gas was maintained throughout the continuance of each experiment. Sometimes, if the animal seemed oppressed, the current of gas was quickened for a time. It was thought that the rate of transmission, with the assistance of the sodium hydroxide solution, was sufficient to keep the excretory gases removed.

Five experiments were made, and in all but the second the animals were watched practically continuously. In the second the watching was continued for the first nineteen hours, and after that the time between observations was never longer than four hours.

First Experiment.—In this experiment a grown male cat was confined in the respiration chamber at five P. M., April 15, 1899. From the nature of the arrangements, observations could be made upon the respiration and general behavior only. In this, as in all of the experiments, the animal was put into the chamber while it was filled with air, and this was gradually displaced by the oxygen. The cat remained in the apparatus until 10:45 o'clock A. M. the next day, or nearly thirty hours. The table below is a record of the observations made:

Time. P. M.	Respiration. Rate per min.	Remarks.
5:00	24	Just before putting into the apparatus.
5:30	24	Asleep.
6:00	29–30	Awake; lying still.
6:30	32	Asleep.
7:30	30–32	Awake; lying still.
8:00	31–32	Asleep.
10:00	32–33	Asleep.
12:00	32–33	Up; looking around.
A. M.		
3:30	34–35	Asleep.
4:30	——	Moving around; breathing a little short.
5:00	34	Sitting up.
6:00	41–42	Breathing short and jerky.
7:30	38	Sat on haunches and ate some.
8:30	35	Asleep.
10:00	27	Looking around.
10:45	——	Termination of experiment.

The only time that the animal gave any signs of distress was when his respiration was short and jerky, but these symptoms did not last long. During the progress of the experiment we had from time to time tested the outgoing gas by means of a splinter with a spark at the tip. On plunging this into the exit tube the spark would burst into a blaze. At 10:45, on performing this experiment, an explosion took place which blew off the lid, and broke the glass front out of the apparatus, thus bringing the experiment to an untimely end. The cat was singed somewhat by the explosion, and was a little stiff from his confinement, but otherwise seemed to be unaffected. His respiration had become about normal, and we have no reason to doubt that he might have lived there indefinitely had oxygen been supplied and no accident supervened.

In respect to the cause of the explosion, which must have been due to the production of some combustible gas, the only explanation that we can suggest is, that the gas may have been of intestinal origin. It is very surprising to us that the quantity could be sufficient to produce the result observed. The oxygen itself was tested and found to be non-explosive, and, in fact, the cylinders had never been used for holding hydrogen or other combustible gases. Had time permitted, we would have been glad to pursue this phase of the subject further, but were unable to at the time.

Second Experiment.—A white rabbit was placed under the same conditions as the cat, and similar observations made. The notes are omitted, as no noticeable change took place. After fifty-three hours the rabbit was removed, apparently in as good condition as when he went in. Grass and clover were eaten heartily during the experiment.

Third Experiment.—In this case a bantam hen and an ordinary chicken about four weeks old were put into the respiration chamber together. They were provided with perches. The little chicken had a hard time of it, as the old hen fought it almost constantly while awake. They remained in the oxygen forty-four hours and seemed to be in perfect condition at the conclusion of the experiment. At one time, when the current of oxygen was somewhat slow, they showed some gasping and were depressed in spirits. This was about three hours before the conclusion of the experiment, and on turning on a more rapid current of the oxygen, the symptoms entirely disappeared, the old hen became quite lively, and began to chase the little chicken again, and abused it severely until the close of the experiment.

Fourth Experiment.—The rabbit used in the second experiment was again confined in the apparatus for twenty hours, then immediately killed and dissected. No change could be detected in the organs. The blood seemed to clot more rapidly than normally, and the arterial blood was of a brighter hue. The venous blood was also probably a very little changed in color.

Fifth Experiment.—Two bantam hens were placed in the apparatus under the same conditions as in the third experiment. They were kept there for six days and twenty-one hours. We had planned to continue the experiment a full week, but the oxygen supply became exhausted. We could not see that they were affected in the least at any time.

From these experiments, we feel justified in concluding that an atmosphere of oxygen produces no permanent excitation, and no unnatural sleep or unconsciousness, and is not destructive to animal life.

EFFECT UPON THE COMPOSITION OF THE SOIL OF CONTINUOUS CROPPING BY WHEAT.

BY J. T. WILLARD, EXPERIMENT STATION, MANHATTAN.

Read before the Academy December 28, 1900.

In the fall of 1880, Prof. E. M. Shelton, of the Kansas State Agricultural College, laid out an acre of land to be devoted to the continuous production of winter wheat, without fertilization or renovating treatment of any kind. This experiment was doubtless suggested by the famous plat at Rothamsted, England, which Lawes and Gilbert have kept under such conditions since 1844. Unfortunately the plat selected by Professor Shelton was situated so that the growth of the institution has seemed to compel the abandonment of the experiment. The plat also, having a rather pronounced slope, was not as well adapted to the purpose of the experiment as would be desirable.

The abandonment of the experiment having been determined upon, it seemed of interest to make analyses of the soil of the plat, and, for comparison, of that of the adjoining field, which has borne a variety of crops, though not in any regular rotation. For sampling these fields four spots were selected in each, and pits sunk to the depth of the proposed sampling. A prism of soil six inches square was then cut from the side of each and divided into four parts, representing, respectively, the first nine inches from the top, and three intervals below this of twelve inches each. Four samples were thus obtained from each field for each depth. These four samples were then intimately mixed to form a composite sample, which was carefully air dried and subsampled for analysis.

The analyses were limited to determinations of the moisture, insoluble residue, potash, lime, nitrogen, and phosphoric acid. The accompanying table exhibits the results as calculated to a water-free basis:

TABLE showing (I) composition of soil at several depths, from field cropped in wheat continuously for eighteen years; and (II) that from an adjacent field that had borne a variety of crops during the same period. Results calculated to a water-free basis, and in percentages.

	0 to 9 ins.		9 to 21 ins.		21 to 33 ins.		33 to 45 ins.	
	I.	II.	I.	II.	I.	II.	I.	II.
Potash	0.720	0.656	0.584	0.716	0.653	0.631	0.615	0.694
Lime	0.750	0.686	0.740	0.722	0.733	0.611	0.811	0.826
Nitrogen	0.216	0.245	0.169	0.152	0.104	0.117	0.087	0.081
Phosphoric acid	0.107	0.140	0.044	0.092	0.017	0.053	0.028	0.161
Insoluble residue	83.948	83.107	81.524	80.723	84.335	83.004	85.281	

The analyses show the soils in both plats to be well supplied with the essential constituents, with the exception of phosphoric acid. This, while about the average in plat II, seems to have become considerably depleted in the plat kept continuously in wheat.

It will be interesting in this connection to note the product of grain during the eighteen years that the experiment continued. The following figures are as published in bulletin No. 71 of the Experiment Station, excepting for the last year, which is from press bulletin No. 1. The year of harvest and the yield in bushels of grain are given:

1881 ..... 9.00	1887, winter-killed.	1893..... 11.65
1882 ..... 47.00	1888..... 30.31	1894..... 6.05
1883 ..... 28.19	1889..... 37.00	1895, winter-killed.
1884 ..... 37.00	1890..... 22.90	1896..... 24.85
1885 ..... 12.30	1891..... 30.75	1897..... 4.43
1886, winter-killed.	1892..... 31.30	1898..... 9.77

The total yield for the eighteen years was 342.5 bushels, an average of nineteen bushels per acre. This period includes three years in which the crop was winter-killed, and two more in which it was partially winter-killed. The soil is an upland, and would be regarded as of only moderate fertility, in view of which the yield obtained must be regarded as quite satisfactory. It will be noticed that during the last third of the period the product was materially less than previously, but whether this is due to soil exhaustion or merely to exigencies of the season must be left undecided.

The analyses of soil given above were made for me by Mr. A. G. Adjemian.

SILICA CEMENT MORTARS.

BY W. TWEEDDALE, TOPEKA.

Read before the Academy, at McPherson, December 29, 1899.

Cement plaster, a product of Kansas extensively used instead of lime mortar for plastering the inside of buildings, has been fully described in the fifth volume of report of the University Geological Survey of Kansas. I desire in the same line to present to you, for your information, another Kansas product which gives promise of being even of greater value as a constituent of mortar; which, possessing hydraulic properties, combines economy in cost with adaptability to all classes of masonry or concrete construction, from the heaviest foundation to the finest statuary. In said report it is termed volcanic ash; it is found of different degrees of purity, in practically inexhaustible quantities in a number of places in Kansas; it consists of silica, nearly white in color, and under the microscope appears to be in thin, transparent scales, overlapping each other, instead of, as in the case of grains of sand, being rounded, irregular particles.

To understand the value of silica as an ingredient of cement mortar, it will be of interest and tend to clearness to explain the characteristics and distinguishing differences, not only between lime mortar and cement mortars, but also between cement mortars of different kinds. These differences are both chemical and physical.

Lime, as a constituent of lime mortar, is an oxide of lime manufactured from a carbonate of lime, as limestone, chalk, or marble, by driving off the carbonic acid by means of heat in especially prepared kilns. This lime, when slaked with

water and mixed with sand, constitutes lime mortar, the proportioning of the ingredients and mode of manipulating them being varied to suit the required uses.

The qualities of a good mortar are that it will "set" or harden into a substance of great strength; that it will adhere firmly to the surfaces which it joins together; and that it will preserve its hardness and strength under atmospheric influences. The setting of both lime and cement mortars is due to chemical changes in the mass of the mortar; it is, however, of an entirely different nature in the case of lime and cement mortars. In the case of lime mortar, the setting is due to the absorption from the atmosphere of carbonic-acid gas, which is absorbed by and combines chemically with the calcium of the hydrate of lime, forming carbonate of lime, and at the same time giving off water. This setting of lime mortar is dependent upon access to the atmosphere, from which it obtains carbonic acid. The hardening, therefore, must be from the outside and extend inwards at diminishing rates; this of necessity precludes the use of lime mortar for masonry under water. The giving off of water in the setting of lime mortar explains why walls built with lime mortar remain damp for such a length of time, rendering newly-built houses unhealthy.

Cement possessing hydraulic properties is manufactured from limestone or marl containing about one-fifth part of clay; this clay consists of alumina and silica.

There are two kinds of cement, natural and artificial (or Portland). Since these cements will not slake in water, they will require to be ground. While both these cements will set under water and harden throughout their whole mass, they possess distinct characteristics, both chemical and physical. Natural cements are those in which the burning has not been carried to the point of vitrification, while artificial (or Portland) cements are those in which this has been done. The quality of the cement is also affected by the proportions of the ingredients and the mode of manipulation. The underburning of the natural cements merely drives off the carbonic acid from the limestone, and changes the clay to a substance akin to brick, the result being in the nature of a mechanical mixture, corresponding to that of lime with pozzuolana, forming the hydraulic lime of the Romans and of the early English engineers. The burning to vitrification of a properly proportioned mechanical mixture of carbonate of lime and clay effects a chemical combination of the constituents forming calcium aluminates and calcium silicates, the quick setting being due to the aluminates and the strength to the silicates.

Examined under a microscope, the physical appearance of natural cement is a mass of nodular particles analogous to that of sand, while Portland cement appears to be a mass of overlapping and interlacing scales.

Mortar consists of an aggregate of sand mixed with a cementing substance, as lime or cement, with suitable quantity of water to bring it to the desired degree of consistency, as the voids between the sand particles are nearly one-half the volume of the sand. Absolute density will only be obtained when that quantity of cement is used, or the mortar is cement 1, sand 2. With lime as the cement material, the case is somewhat different, as the water adds considerable to the volume of the hydrate of lime; hence, the filling of the voids will be attained with less than that quantity of lime. In practice, less than one-half volume of cement will also serve; the usual practice for good work is to make mortar in proportion of 1 to 3.

Portland cement is ground to a certain prescribed fineness: (1) Because the coarser particles do not set, but remain inert, as so much sand. (2) Because the finer the particles the greater surface of sand they will cover.

To make a strong and reliable cement mortar there should be sufficient cement to fill the voids of the sand, and it should be evenly distributed in the mortar. By careful mixing, less cement than 1 to 3 will give fairly good results; but with the ordinary workman it is not safe to do so, for which reasons it is in many cases necessary to use a cement mortar of greater strength than is required. To overcome this unnecesary cost it has been sought to use a portion of lime mixed with the cement.

For reasons above given of the different causes of setting of lime and cement, this has not been found to be satisfactory; hence, it is extremely desirable to devise some method of making a mortar combining as nearly as possible the low cost of lime mortar with the strength and durability of cement mortar, suited to the special requirements. To meet this demand, F. L. Smidth, C. E., of Copenhagen, invented a process that satisfies these requirements when the conditions allow of the use of a mortar of less strength than would be obtained with proportion of one to three. This process consists in mixing cement and sand in the requisite proportions, and then in a special mill pulverizing them to a fine powder. This product is termed "sand cement," and is then used as ordinary Portland cement, when mixed with the usual proportions of sand and water to form a mortar, in which the voids of the finely ground sand are filled with cement and the voids of the coarser sand are filled with the sand cement, thus satisfying the requirements of filling the voids and also uniformly distributing the cement throughout the mass of the mortar.

Experiments made with lime mortar, hybrid mortar and cement mortars of different proportions of cement and sand gave as follows:

Briquette of lime; broke at 36 lbs.
Briquette of cement 1, lime 5; broke at 111 lbs.
Briquette of sand cement: { cement 1, sand 28½; broke at 118 lbs.
cement 1, sand 35; broke at 100 lbs.
cement 1, sand 38; broke at 67 lbs.

In actual building with sand-cement mortar, the theoretical advantages above set forth have been surpassed.

A laboratory building was erected in Sweden in which sand cement was successfully used in proportions of cement 1, sand 51. The advantages obtained by the use of sand cement led to the erection of several plants in Europe, one in Brooklyn, and one at Glens Falls, N. Y. The cost of plant and the freight on sand has restricted the use of sand cement to where sand is plentiful and the building to be erected is of some magnitude. The foundation for the cathedral of St. John the Divine in New York city was of this material. The time required for grinding 2100 pounds at the Brooklyn works was one and three-fourths hours.

We found that there is the same physical difference between the form of the particles of silica and of ground sand as between those of natural cement and Portland cement; a fact that will justify us in believing that silica cement will be of greater value as an ingredient of mortars than sand cement. The fineness we found was an important factor in the value of sand cement. That as made at the Brooklyn works was ten per cent. residue in a 180-mesh sieve; while silica obtained from McPherson gave a residue of four per cent. in a 200-mesh sieve.

THE ATCHISON DIAMOND-DRILL PROSPECT HOLE.

BY A. E. LANGWORTHY, ATCHISON.

Read before the Academy, at Topeka, December 28, 1900.

In the spring of 1899, Mr. Chas. Crawford, a coal dealer of Atchison, mentioned to Mr. S. C. King, of the executive committee of the committee of forty, that Mr. J. E. Carr was about to retire from the management of the North Leavenworth Coal Company, and incidentally told Mr. King that Mr. Carr believed the same seam of coal existed under Atchison as that mined at Leavenworth.

Mr. King wrote Mr. Carr inviting him to come to Atchison and look over the situation. Mr. Carr and his son did so and gave it as their opinion that coal existed; but they expressed a wish to see the records of the prospect holes which had been drilled in and about the city. When the writer learned of this desire on the part of the Messrs. Carr he at once placed at their disposal copies of such university reports and transactions of this Academy as he had.

The writer then became interested in the matter himself and began looking up records which did not appear in those publications. He also began studying the geological formation near Atchison, making numerous trips to various points where there were outcroppings of coal or rock. On one of these trips, in company with Prof. E. B. Knerr, of Midland College, especially valuable information was obtained.

In looking up records much assistance was given by Mr. M. Noll, a pharmacist of Atchison, who furnished several records as well as a chart of a diamond-drill prospect hole at Valley Falls, Kan., about twenty miles southwest of Atchison. This chart was plainly the work of Prof. E. B. Knerr, since the initials "E. B. K." appear in one corner. As neither this chart nor a record of the prospecting at Valley Falls has, to the knowledge of the writer, ever been published, the description accompanying the chart is quoted in full, in connection with this paper.

RECORD of diamond-drill hole at Valley Falls, Kan., drilled in 1888, by Ingells Bros., of Atchison, Kan. First column of figures shows thickness of strata, in feet; second column shows total depth of hole, in feet.

Soil	8	8
Gravel	9	17
Shale	17	34
Gravel	3	37
Sandstone	3	40
"Granite" rock	16	56
White limestone	12	68
Shale	22	90
Limestone	15	105
"Magnesia"	3	108
Limestone	12	120
Blue shale	5	125
Limestone	10	135
Shale	40	175
Limestone	4	179
Sandstone	8	187
Shale and limestone mixed	11	198
Shale	5	203
Limestone	22	225
Hard shale	7	232
Limestone	10	242
Hard shale	19	261
Sandy shale	25	286
Soft, light limestone	7	293
Shale	2	295
Soft sandstone	16	311
Shale	14	325
Shale and limestone mixed	15	340
Sandstone, bearing salt water	42	382
Light, soft limestone	2	384
Shale	7	391
Gray sandstone	15	406
White sandstone	9	415
Yellow sandstone	2	417
Dark sandstone	40	457
Shale	1	458
Light sandstone	34	492
Shale, changing to limestone mixed with flint	6	498
Dark shale	2	500
Hard limestone	3	503
Dark shale	1	504
Limestone	2	506
Dark, soft limestone	4	510
Soft, white limestone	8	518
Limestone	13	531
Shale	9	540
Hard limestone, with irregular streaks	23	563
Sandstone	9	572
Shale	1	573
Limestone	4	577
Limestone with streaks of dark shale	10	587
"Honeycomb" stone	3	590
Dark gray "granite"	22	612
Yellow rock, with gravel and shells	3	615
Shale	1	616
Hard limestone	3	619
Shale	3	622

Sandstone	11	633
Sandy soapstone	26	659
Shale	5	664
Sandstone	17	681
Hard limestone	15	696
Shale	7	703
Limestone	13	716
Shaly sandstone	22	738
Limestone	9	747
Shale	3	750
Yellow limestone	10	760
Hard limestone	5	765
Dark shale	4	769
Limestone	8	777
Hard, dark shale	2	779
Soft shale	3	782
Dark shale	4	786
Light shale	2	788
Limestone	18	806
Dark shale	5	811
Limestone	3	814
Dark shale	8	822
Limestone and shale	27	849
Light shale	7	856
Limestone mixed	13	869
Sandy shale	5	874
Soft sandstone	5	879
Hard sandstone	26	905
Sandy shale	14	919
Hard limestone	5	924
Shelly shale	10	934
Light shale	10	944
Limestone	4	948
Dark, soft shale	5	953
Shale mixed with coal and limestone	17	970
Limestone	9	979
Dark and light shale, with shells	12	991
Dark shale	3	994
Coal	1	995
Dark shale, changing to light	12	1007
Light shale, intermixed with limestone and sandy shale (coal marked near top of this stratum, but thickness not given)	20	1027
Light shale, intermixed with limestone	12	1039
Dark shale	3	1042
Light shale	17	1059
Light shale, mixed with limestone	10	1069
Blue shale	2	1071
Light shale, changing to sandstone,	11	1082
Shale	5	1087
Blue shale, turning dark	3	1090
Coal, four inches	..	1090
Dark shale, changing to light, and running into sandstone	12	1102
Coal, six inches	..	1103
Shale	9	1112
Shale mixed with limestone, changing to light sandstone	11	1123
Light and dark shale	7	1130
Dark sandstone	5	1135
Dark shale, with trace of coal	5	1140
Sandstone	9	1149
Light sandstone and shale	5	1154
Light sandstone	7	1161
Light shale and sandstone, with a trace of coal	7	1168

The result of studying the geological formation, as shown at the surface and by the various records of wells, etc., was to convince the writer that Atchison was situated over the Coal Measures. It further seemed probable that a workable seam of coal might be found, in spite of the fact that the published records at that time, especially the record of what was called the Atchison deep boring, appearing in vol. XIV, page 255, of the Transactions of this Academy, gave no indication that such a seam existed. In fact, the records, and in particular the one mentioned, as it showed no coal in a hole 1204 feet deep, gave the impression that coal would *not* be found.

The secretary of the company which drilled the well in question informed the writer, however, that his company did find coal in drilling that hole, which was made with a churn drill. This fact, in connection with the numerous stories to the effect that the correct records had been suppressed by interested parties, confirmed the writer in his belief that workable coal really existed.

A report of what had been found in regard to the geological formation at Atchison was then given the executive committee of the committee of forty. The executive committee sent a subcommittee to Leavenworth to try to interest Mr. Carr again, as he had become rather discouraged on account of the bad showing made by existing records and the lack of authentic reports in other cases. Mr. Carr was induced to visit Atchison again, and he then advised the formation of a stock company for the purpose of prospecting for coal, and mining it, should it be found.

In accordance with this suggestion a company was organized, July 19, 1899, under the name of "The Atchison Mining Company, Limited," of which company the writer was elected secretary. The directors, with the assistance of the committee of forty, raised about $3000 by subscription among the citizens of Atchison. Then the subject dragged for some time. The directors had agreed not to commence operations until they had sufficient money in bank to meet all expenses.

Professor Haworth, of the state university, was then requested to visit Atchi-

son and make a geological survey of the vicinity, in the hope that his report would be favorable and arouse new enthusiasm. This Professor Haworth did, and the report which he sent to Wm. F. Dolan, president of the company, expressed his belief that no well had as yet entirely penetrated the Cherokee shales at Atchison, and that their lower surface would probably be reached there at from 1200 to 1300 feet. The report summed up the whole matter as follows: "It seems to me that the probabilities of a workable vein of coal underlying Atchison are fairly good."

The directors finally collected the subscriptions, but still lacked sufficient money to pay the price asked by reliable diamond-drill companies for the amount of drilling it was desired to do. Later, one of the drill companies, the Sullivan Machinery Company, of Chicago, took a contract to do some drilling near St. Joseph, Mo., nineteen miles northeast of Atchison, for a lower price than they had asked of the Atchison company. This reduction in price was made, presumably, because the state of Missouri would have considerable drilling to do, as it had a fund to be expended in prospecting, under the conditions that, if the prospecting was successful, the parties interested should bear the entire expense, but if unsuccessful, the state was to bear one-half the expense.

When the directors of the Atchison company learned of this reduction in price, they immediately sent Mayor Donald and S. C. King to see the representatives of the Sullivan Machinery Company, at St. Joseph. The price at which the work was being done there was such that the Atchison company could pay for the actual drilling desired; but they were unwilling to proceed without watchmen, and they did not have sufficient money to pay reliable men for watching at the drill day and night. The reason the Atchison company were unwilling to proceed without watchmen was because there were so many stories to the effect that the correct records of some of the old prospect holes had been suppressed; and it was determined that there should never be any question in regard to the correctness of the record they proposed making.

The writer was then sent to St. Joseph to obtain such geological information as was possible, in order that a comparison might be made of the strata at places near Atchison. A complete copy of the record of the St. Joseph well, as far as it had then gone, was obtained; and this compared so favorably with the known record at Leavenworth, twenty miles southeast of Atchison, that it made the directors still more anxious to proceed with the drilling at Atchison. But as the Atchison company did not have sufficient money to pay watchmen, Professor Haworth was appealed to. He responded by agreeing to send Mr. L. N. Morscher, at the expense of the University Geological Survey, to act as one of these watchmen, the writer to act as the other, and to keep a record of the strata passed through, for the survey. In return, the directors agreed to give the university the entire core from the hole.

As it was thus made possible to finish the hole to a depth of 1000 feet with the money then on hand, a contract was made with the Sullivan Machinery Company to drill a prospect hole at Atchison. It was provided in this contract that the hole should be 1500 feet, if necessary; that a two-inch core should be brought up; that the price of the first 1000 feet should be three dollars per foot; that the price of the next 200 feet should be four dollars per foot, and the price of the next 300 feet should be five dollars per foot; that the Atchison company should furnish fuel and water at the drill; and that there should be on deposit, in the bank, at no time less than the contract price of 100 feet of drilling.

Under this contract work was commenced July 23, 1900. At a depth of 799 feet the Leavenworth seam was found; and when a depth of nearly 1000 feet was

reached, without having penetrated the Coal Measures, the city council voted enough money to go to a depth of 1100 feet. When a depth of 1100 feet was reached some of the directors thought best to discontinue the work, as nothing of value had been found in the last 300 feet, and the foreman in charge of the drill had said it was "burning the people's money" to go further. But, as there was hope of finding coal until the Coal Measures had been entirely penetrated, others of the directors thought best to continue, and money for the next 100 feet was raised.

The Sullivan company, however, at first declined to proceed, as the letter of the contract had not been kept by having the contract price of the next 100 feet of drilling in the bank when the 1100 feet were finished, although this money was put in the bank later on during the same day. This matter was finally adjusted, and it was shown that it was due to a misunderstanding that the Sullivan company thus took advantage of a technicality. In order to prove their good faith, the Sullivan company agreed to drill the balance of the distance through the Coal Measures for three dollars per foot.

Under this agreement the drilling proceeded, and a 36-inch seam of coal was found at a depth of 1123 feet; a 28-inch seam at 1187 feet 9 inches; and a 15-inch seam at 1197 feet 6 inches; besides many other small seams, as shown by the appended record. By this record it will be seen that the drill penetrated in all eighteen seams of coal, making a total of fourteen feet five inches, of which at least eight feet is probably workable coal. The core of the coal occurring at 879 feet 5 inches is quite remarkable, in that the bottom of it forms an angle of about forty-five degrees. This shows that the drill penetrated this seam, either where a fault occurs or else where there is a horseback; most likely the latter. The above sketch illustrates the appearance of the core.

From the accompanying table, prepared from an analysis of the Atchison coal, made by Mr. E. B. Hayes, of the university, it appears that it is second only to the Cherokee county coal, and as a gas coal is superior to that.

When the Subcarboniferous, or Mississippian limestone, was reached, at 1315 feet, it was thought best by some of the directors to continue to such a depth that there could be no doubt of having entirely penetrated the Coal Measures. The drill, therefore, penetrated the Mississippian limestone for a distance of thirty-eight feet, the core brought up showing it to have the same marked features which characterize it in the extreme southern part of the state, 200 miles away. This correspondence is further shown by an analysis made by Mr. F. B. Porter, a report of which accompanies this paper.

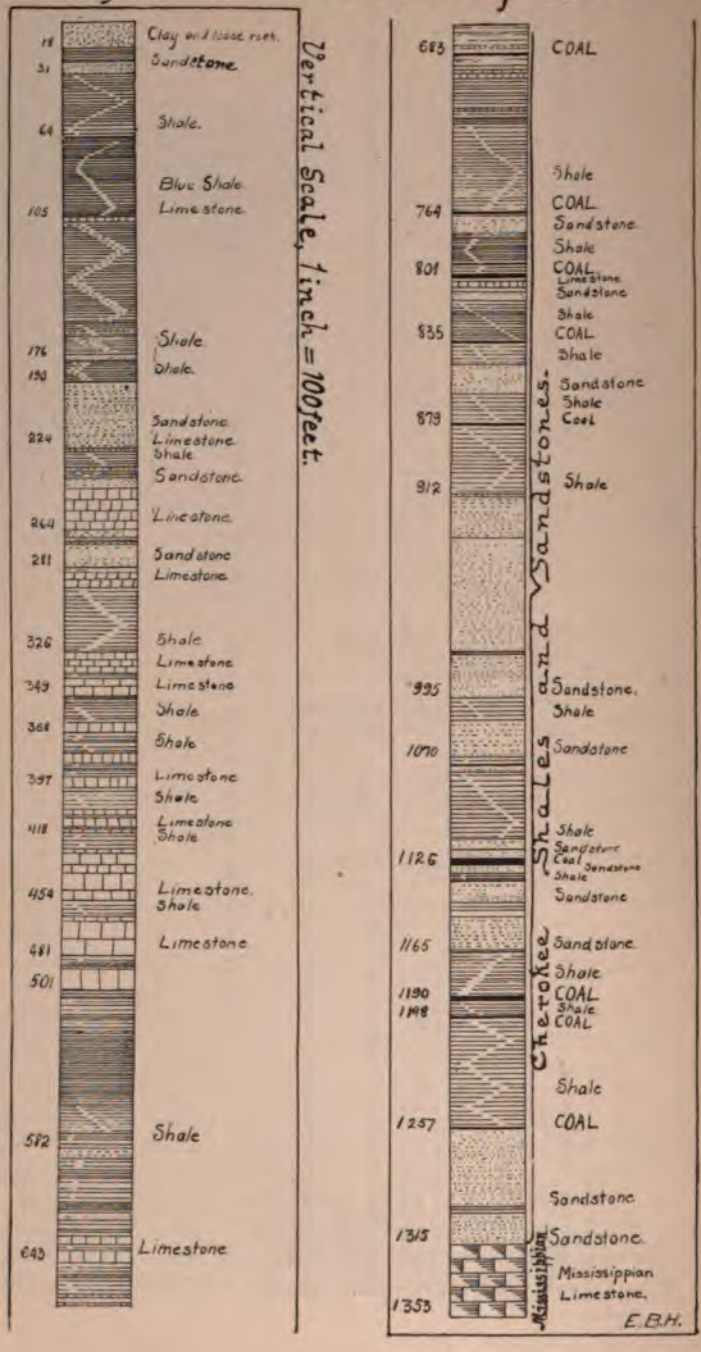
The drilling was completed October 18, 1900, taking nearly three months, an average of one day for each fifteen and one-half feet. The total expenditure by the Atchison company, for all purposes, was about $4700, or, roughly, $3.50 per foot.

COMPARATIVE ANALYSES OF COAL FROM DIAMOND-DRILL CORE AT ATCHISON AND COAL FROM WEIR CITY AND LEAVENWORTH.

	Moisture	Volatile and combustible	Fixed carbon	Total sulphur	Fixed sulphur	Volatile sulphur	Iron as Fe_2O_3	Iron as Fe	Color of ash	Form of ash	Ash
Average sample, 36-inch seam, Atchison	4.48	41.70	46.69	2.62	.0	2.62	3.06	2.15	Grayish pink	Light and flaky	7.13
Duplicate	3.95	42.13	46.81	2.57	.0	2.57			"	" "	7.11
Average	4.21	41.91	46.75	2.59	.0	2.59	3.06	2.15	"	" "	7.12
Best sample, 36-inch seam, Atchison	2.12	44.82	48.14	1.95		1.95			"	" "	4.92
Duplicate	2.00	44.50	48.49	1.96		1.96			"	" "	5.01
Average	2.06	44.66	48.31	1.955		1.955			"	" "	4.96
Total average, 36-inch seam, Atchison	3.13	43.29	47.53	2.27	.0	2.27			"	" "	6.04
Total average, seven samples, Weir City	2.85	37.11	54.36	1.58	.44	1.71					5.66
Difference	.28	6.18	6.83	.69	.44	.56					.38
Lower sixteen inches of 22-in. seam, Atchison	2.89	38.71	43.92	6.33	.11				Reddish brown	Rather coarse and slight clinker	14.48
Duplicate	2.63	39.27	43.69	6.15	.10				"	" "	14.41
Average	2.76	38.99	43.80	6.24	.105				"	" "	14.44
Total average, four samples, Leavenworth	4.63	36.37	40.66								13.33
Difference	1.87	2.62	3.04								1.11

Total combustible material in total average { of 36-inch seam, Atchison 93.09
{ of Weir City samples 93.18
Difference 0.09

Vertical Section of the Atchison Diamond Drill Prospect Hole.



Log of Atchison deep well, located on Missouri Pacific railroad, two and one-half miles south of Atchison, commenced July 23, 1900. First column of figures shows thickness of strata, in feet and inches; second column shows total depth of hole, in feet and inches.

Clay and loose rock	18	18
Clay shale	6	24
Sandstone	7	31
Blue shale	33	64
Sandstone	1-2	65-2
Blue shale	39-10	105
Conglomerate	2	107
Sand shale	53	160
Sandstone	7	167
Blue shale	9	176
Sandstone	3	179
Sand shale	11	190
Sandstone	34	224
Limestone	2	226
Blue shale	8	234
Sandstone	2	236
Sand shale	3	239
Sandstone	5	244
Limestone	20	264
Sandstone	4	268
Limestone	1	269
Sandstone	12	281
Blue shale	2	283
Limestone	8	291
Sandy shale	35	326
Limestone	11	337
Blue shale	3	340
Limestone	9	349
Blue shale	2-8	351-8
Black shale	1-4	353
Limestone	1	354
Blue shale	9	363
Limestone	5	368
Green shale	5	373
Blue shale	5	378
Limestone	5	383
Shale mixed with limestone	4	387
Limy shale	1	388
Blue shale	4	392
Limestone	5	397
Black shale	2	399
Blue shale	9	408
Limestone	3	411
Blue shale	1	412
Conglomerate	8	420
Blue shale	7	427
Conglomerate	2-6	429-6
Limestone	5-6	435
Conglomerate	4	439
Limestone	15	454
Blue shale	8	462
Limestone	19	481
Black shale	4	485
Limestone	16-6	501-6
Blue shale	1	502-6
Sandy shale	5-6	508
Sandstone	5	513
COAL	0-1	513-1
Sandy shale	5-11	519
Limestone	1	520
Sandy shale	42	562
Clay shale	15	577
Blue shale	7	584
Sandstone	5	589
Clay shale	24-6	613-6
Limestone	0-6	614
Clay shale	4	618
Sandstone	4	622
Blue shale	2	624
Clay shale	3-6	627-6
COAL, slaty	0-3	627-9
Black shale, limestone bands	1-3	629
Soft shale, or fire-clay	2	631
Limestone	4	635
Shale, limestone bands	8	643
Blue shale	6	649
Shale mixed with lime	2	651
Blue shale	2	653
Shale, lime bands	5	658
Soft clay shale	2	660
Limestone	2	662
Sandy shale	9	671
Black slate	7-6	678-6
Limestone	1-6	680
Black slate	2-4	682-4
COAL	0-10	683-2
Dark shale	0-10	684
Black shale	1	685
Limy shale	2	687
Limestone	5	692
Limy shale	2	694
Limestone	3	697
Dark shale	6	703
Clay shale	4	707
Limestone	1	708
Shale mixed with lime	4	712
Limestone	1	713
Limy shale	3	716
Black shale, limestone boulders	2-6	718-6
Soft, sandy shale	4-6	723
Blue shale	40	763
Hard, black shale	0-10	763-10
COAL, shale partings	0-10	764-8
Sandstone, shale partings	10-4	775
Hard, black shale	2	777
Black shale	0-9½	777-9½
COAL	0-2½	778
Shale, streaks of sand	15	793
Dark shale, limestone bands in it	6	799
COAL	1-10	800-10
Soft shale	3-8	804-6
Lime and shale	3-6	808
Soft shale	2-6	810-6
Sandy shale	8-6	819
Blue shale, very soft, no core	4	823
Blue shale	0-6	823-6
Limestone and shale	4-6	828
Soft shale	2	830
Sandy shale	3-6	833-6
Black shale	1	834-6
COAL	1	835-6
Sandy shale	4-6	840
Soft shale	3	843
Sandy shale	8	851
Sandstone	9	860
Sandy shale	5	865
Sandstone	1	866
Sandy shale	4	870
Dark shale	8-5	878-5
COAL	0-9	879-2
Soft shale, or fire-clay	2-10	882
Soft shale, limestone chunks	4	886
Sandy shale	3	889
Limy shale and shale	3	892
Sandstone	11	903
Sandy shale	6	909
Sandstone, shale partings	49	958
Sandstone	38	996
COAL	0-1	996-1
Shale and limestone	0-5	996-6
Sandstone	23-6	1020
Shale	3	1023
Sand shale	27	1050
Sandstone, coal partings	20	1070
Clay shale	1	1071
Sandy shale	3	1074
COAL	0-2½	1074-2½
Dark sandstone	1-9½	1076
Sand shale	10	1086
Shale, sandstone partings	18	1104
Sandstone, shale partings	15	1119
Black shale	0-10	1119-10
COAL	0-1	1119-11
Shaly sandstone	3-1	1123
Sandstone and lime	0-6	1123-6
COAL	3	1126-6
Hard sand, with lime in it	3	1130
Dark-blue shale	3-9	1133-9
COAL	0-6	1134-3
Sandstone, shale partings	10-9	1145
Dark shale	7	1152
COAL	0-4	1152-4
Sand and limestone	3-8	1156
Sandstone, shale partings	10	1166

Black shale	0-6	1166-6
COAL	0-2	1166-8
Dark-blue shale	3-4	1170
Hard, black shale	5	1175
Hard, dark shale, lime in it	2	1177
Hard, black, laminated shale	10-9	1187-9
COAL	2-4	1190-1
Dark shale	0-11	1191
Dark slate	6-6	1197-6
COAL	1-3	1198-9
Dark slate	2-3	1201
Dark shale	19	1220
Dark, sandy shale	28	1248
Dark, sticky shale	8-6	1256-6
COAL	0-11	1257-5
Sandstone	0-1	1257-6
Sandstone, shale partings	9-6	1267
Sandstone, dark partings	20	1287
Sandstone, shale partings	10	1297
Hard, black shale	2	1299
White sandstone	8	1307
Sandstone	8	1315
Limestone	38	1353

ANALYSES OF THE MISSISSIPPIAN (SUBCARBONIFEROUS) LIMESTONE FROM THE ATCHISON PROSPECT WELL.

BY FRED B. PORTER, LAWRENCE.

Read before the Academy, at Topeka, December 29, 1900.

After the core of the diamond-drill prospect well at Atchison was brought to the University of Kansas, two samples of the lowest strata reached by the well were analyzed in the quantitative chemical laboratory, under the direction of Prof. Edward Bartow. A sample from a point twenty-six feet from the bottom and 1124 feet below the surface was analyzed by Maud Hodgdon, and a second sample, from the last six inches of the core, was analyzed by N. L. Stewart and the writer.

The results of the analyses are as follows:

	No. 1. Hodgdon.	No. 2. Stewart.	No. 3. Porter.
Silicious matter	2.34	.....	3.63
Silica (SiO_2)	.....	2.27*	.....
Iron oxid (Fe_2O_3)	.....	.49*	.....
Aluminum oxid (Al_2O_3)	.65	.34*	.36
Calcium oxid (CaO)	52.98	52.45*	53.11
Magnesium oxid (MgO)	.52	.72	.48
Carbon dioxid (CO_2), calculated for CaO and MgO	42.16	42.02*	42.29*
Carbon dioxid, determined	(.....)	(42.41)	(42.15)
Moisture (H_2O)	.08	.14	.09
Totals	98.73	98.43	99.96

The analyses marked (*) are from single determinations; the remainder, from an average of two or more.

A hypothetical combination of the above constituents is as follows:

	No. 1.	No. 2.	No. 3.	Galena.
Silicious matter, or SiO_2	2.34	2.27	3.63	1.00
Iron and aluminum oxids	.65	.83	.36	.69
Calcium carbonate ($CaCO_3$)	94.58	93.68	94.84	97.32
Magnesium carbonate ($MgCO_3$)	1.08	1.51	1.04	.80
Water (H_2O)	.08	.14	.09	.....
Totals	98.73	98.43	99.96	99.81

Column 4 gives an analysis of the Subcarboniferous from Galena, recorded in the United States Geological Survey for 1894, part IV, page 505, and shows the relation of composition of the same strata in two localities.

ANALYSIS OF MAGNESIA WATER FOUND NEAR MADISON, KAN.

BY F. W. BUSHONG, COLLEGE OF EMPORIA, EMPORIA.

Read before the Academy December 29, 1899.

The following is an analysis of well-water from the farm of Mr. Arnold Girard, Madison, Kan., section 2, township 22 south, range 12 east; depth of well about thirty feet:

Substances (estimated) per liter.		Corresponding to the following salts, calculated in 1,000,000 parts:	
SiO_2	0.0128 grams.	Silica (SiO_2)	13 parts.
Fe_2O_3 and Al_2O_3	0.0118 "	Clay bases (Fe_2O_3 and Al_2O_3),	12 "
CaO	0.5712 "	Magnesium sulph. ($MgSO_4$),	1,903 "
MgO	0.6403 "	Calcium sulphate ($CaSO_4$),	830 "
Na_2O	0.7042 "	Calcium carbonate ($CaCO_3$),	396 "
Na_2CO_3	0.0636 "	Sodium sulphate (Na_2SO_4),	1,380 "
SO_3	2.5446 "	Sodium carbonate (Na_2CO_3),	63 "
Cl	0.0698 "	Sodium chlorate ($NaCl$)	115 "

THE MUSCOTAH ARTESIAN WELLS.

BY E. B. KNERR, MIDLAND COLLEGE, ATCHISON.

Read at Topeka December 28, 1900.

Along the base of the east bluffs of the Grasshopper valley, about one and a half miles south of Muscotah, there are a series of interesting low, marshy mounds. The mounded area on the farm of Mr. H. M. Rice is about a hundred rods long by fifteen rods wide, and the mounds are five to eight feet high. About a quarter of a mile farther south, on S. H. Hubbard's farm, is another mound, about fifteen yards wide, sixty yards long, and eight or ten feet high. Two miles farther south, on James Miller's place, there are similar mounds. A swamp is usually low ground, but here the swampy ground is the highest. Early in September, 1900, Mr. Rice concluded that if he were to sink a pipe near one of these mounds he would get an artesian flow of water. He bored a test hole with a two-inch auger, and at a depth of thirty-four feet struck a flow of water so strong as to force up pebbles the size of hickory-nuts. A two-inch pipe was forced into the hole, and the water rose to overflow this when it stood fifteen feet above ground. The flow from this two-inch pipe is fifty gallons every fifty-five seconds. The water is as clear as crystal, very palatable and cold, registering a temperature of fifty-six degrees F. The water deposits a slight iron coating over the barrel into which it flows. Calcareous deposits are also found in places about the mounds, indicating mineral properties for the water.

The formation of the mounds is explained by the water pressure carrying up sand and soil and depositing it at the surface. The mounds are covered by bulrushes, cattails, and other usual swamp growth, which holds the soil, preventing its being washed down. The water springs from over the whole surface of the mounds, and away in small streams. Thus, the peculiar circumstance arises that the swamp is high ground, and the firm soil is lower. The date of the above observations was Saturday, September 22, 1900.

Analysis of the water gave the following results per liter:

SiO_2	.0280 grams.	Na_2O	.0244 grams.
SO_3	.0550 "	H_2O combined	.0746 "
Cl	.0176 "	CO_2 combined	.3644 "
FeO	.0454 "	Total	.8320 "
CaO	.1625 "	Less Cl as O	.0040 "
MgO	.0356 "	Total solids	.8280 "
K_2O	.0245 "		

The probable combination in grains, per U. S. gallon, is as follows:

SiO_2	1.6324	$MgH_2(CO_3)_2$	5.1712
NaCl	1.6907	$CaH_2(CO_3)_2$	27.4126
Na_2SO_4	1.2010	$FeH_2(CO_3)_2$	6.5471
K_2SO_4	2.6410	Total solids	48.2724
$MgSO_4$	1.9764		

WATER-SUPPLY FROM A SANITARY STANDPOINT.

BY F. O. MARVIN, C. E., UNIVERSITY OF KANSAS, LAWRENCE.

A lecture delivered before a special meeting of the Academy, at Topeka, January 25, 1901.

As a close student of the animated forces of nature becomes more and more familiar with the various individual species that make up the complicated fauna and flora, and with the way in which she carries on the life processes of the different organizations, the more is he forced to a recognition of the fact that there is a constant struggle for individual existence. Life preys upon life. The higher types attack and kill the lower, appropriating them for food or getting them out of the way if inimical to their development. In turn, throughout the whole range of living organisms, the lower resists this attack and appropriation, and through the multiplicity of numbers or a counter-attack in the domain of parasitism, seeks to maintain and perpetuate its own. Just in proportion as any type acquires an ability to ward off attack from its enemies on the one hand, and on the other to utilize the vital energies of those of the lower types that can assist in any way in its own permanence, does it have chance of a natural and continuous evolution of its own traits and characteristics.

Man himself is not exempt from this struggle, but he has the advantage of a higher intelligence, which, unfortunately, he does not always exercise to his benefit. He often so orders and conducts the affairs of his daily life as to create conditions favorable to the rapid and continued development of his natural enemies, while neglecting those that favor his natural friends.

Air, water, food and the soil are the natural possessions of man, and each individual has an inalienable right to their use. If he is to derive the maximum of benefit from the exercise of this right, these elements must contain nothing that is harmful to him; that is to say, that the air must be clean, the water safe, the food good, and the soil unpolluted. Absolute purity in these elements has no practical existence, and it is useless to insist on such; but it is well within the individual right to demand that these shall be free from harmful contaminations, so that they may be used with safety. This individual right also carries with it an individual responsibility, viz., the avoidance of any personal act, whether willful or otherwise, that may render these elements unsafe to others.

Primitive man could easily move his local habitation to one of better environment when he found the results of his own living were detrimental to either him-

self or his neighbor. Modern man, on the contrary, is a fixture in one location, and this, together with his gregarious habits, tends to a concentration of the waste products of his own activity, a system of life that we boastfully call civilization. This brings evil through rendering these common heritages unsafe for use. The very best and keenest intelligence of the race has been and is being brought to bear on the problems that have arisen under these conditions. Much has been learned of the means to be employed to avoid or lessen its effects, but there are still many things that are seen but imperfectly—many problems still unsolved. It is the province of this paper to briefly summarize the condition of our knowledge with reference to one of these elements, viz., water. In view of the fact that nearly five-sixths of the human body is composed of water, and that five or six pints are required daily for its sustenance, it would seem that every intelligent person possessing a lively instinct of self-preservation should desire to be possessed of all possible knowledge relating to its quality and the matters carried by it.

The sources from which supplies are obtained are four: From cisterns that catch and store the rainfall from roofs; shallow wells for the supply of isolated dwellings, or, when built larger or coupled together, for the supply of towns; deep wells, furnishing artesian water; rivers, or lakes and ponds, either natural or artificial. The common source is the rainfall, and it may clear the discussion if we trace this through its various stages, before it appears in a private or public supply. The water vapor that has arisen from the surface of land or ocean is condensed and falls as rain, washing the air of its mineral and organic dust, and absorbing also soluble gases, if any are present—ammonia, carbon dioxid, sulphur oxids, etc. Even the rainfall, then, is not pure water, and when gathered from city roofs it is further made more impure by the roof washings; so that cisterns often contain a considerable quantity of mineral and organic matter, either dissolved in the water or found at the bottom in a putrescent mass. In the smaller towns it is not likely that the amount and character of such impurity will be detrimental to the health of those that use the water, if cisterns are kept reasonably clean; but in larger places, where dust and smoke are much more abundant, such water may be at least objectionable to the senses of sight and smell, if not absolutely harmful.

When the rain falls on the ground it gives up to the vegetation its ammonia, and in return takes up from the soluble rocks certain of their salts and washes from the soil its earthy or organic dust, thus becoming richer in carbon dioxide and albuminoid ammonia, and with increased solvent power. Flowing from the highlands to the regions of forest and plain, various organic substances are extracted which add to the impurity of the water, and often give it a decided color. An undulating country, underlaid by sandstone formations and covered by a succession of forest and meadow and peaty bog, furnishes a brown or amber water, the color being derived chiefly from decomposed and caramelized carbonaceous matter. The water flowing from a limestone region, where the rocks are of a more soluble character and have given up some of their elements, is more apt to be colorless, though harder than the brown waters, and often containing as much, or more, organic matter. The rills and rivulets run together to form the larger streams, adding constantly to their burden of suspended or dissolved matter, both mineral and organic. The former kind of these impurities does not trouble the sanitarian when dealing with a surface-water, unless the matter is present in an excessive amount, as is the case with some of our larger western rivers. And here the difficulty is one connected with the appearance of the water or the disagreeableness of its use, rather than on account of any direct bearing that the

presence of the mineral constituents may have upon the health of the consumers. But with the organic matters of a water we have much to do, because these do have an influence upon health.

It is, then, essential that we should know in what ways this organic matter appears in a water, what changes it undergoes, what life activities accompany these, what becomes of it, how its history is recorded, and how all this is related to its safe use. It must be said in the outset that even such amounts of organic matter as would offend the sight or our sense of smell are not necessarily injurious to the human system. It is probable that they do affect us by weakening our power of resistance when attacked by disease, but we do not know as yet in just what way. However, observation and experience have taught us that its presence is frequently accompanied by living organisms that seek to fasten upon us, to set up disease or cause death. Hence, to the analyst or engineer who is called upon to judge of the character of a water as to its fitness for human use, the mere presence of these organic matters will not lead to a condemnation, but will be regarded as a danger signal which it is wise to heed, even to the total rejection of the water when the organic matter indicates conditions favorable to the presence of disease germs.

In making an analysis of water the chemist singles out the nitrogen as the significant substance, because this forms so large a part of the objectionable matter. In the first stages of the change in vegetable or animal tissue, this appears in the form of certain compounds of ammonia which are derived from the organic nitrogen of dead matter through the agency of several forms of low plant life—the molds, fungi, and certain species of bacteria, which attack it and break it up. This is the process of putrefaction. It may take place in the absence of air, and may be accompanied with the evolution of foul odors. When the insoluble organic nitrogen has been thus changed into the soluble forms of albuminoid and free ammonia, these in turn are attacked and broken up into new compounds by other species of bacteria, provided that there is present a sufficient small amount of oxygen, as this is a necessary element of their life. In the result, the nitrogen, as nitrous acid, unites with various bases to form nitrites. Then another set of bacteria requiring more oxygen work these over into nitrates, a final stage, when the nitrogen has lost its organic character and become completely oxidized and mineralized.

The principal factors in bringing about all these changes are the bacteria, a class of very minute microscopic plants, very little known twenty-five years ago, but which have been recently studied the world over. We have learned many things about them, and have put some of them at work to do our bidding, illustrations of which will be spoken of later.

But we have not done with the changes that take place in our nitrogen. After it has reached the condition of nitrates it is in proper form to become the food of plants higher in the scale than those that had used it before. These are small, almost microscopic, chlorophyll-bearing plants, and consequently having greenish colors, that float about freely in the water or become attached to larger growths. They appropriate the nitrates and restore them again to organic forms within their own structure. Then these algæ become the food of the lower animal life, or, perhaps, die from excess of numbers or lack of sufficient food; when the dead matter is attacked anew by the bacteria. This completes the cycle of the nitrogen—organic nitrogen, the soluble ammonia compounds, the nitrites, the nitrates, and back again to organic state.

This cycle is not always complete. If the ammonia compounds are set free under conditions of little or no oxygen, the nitrifying organisms do not find all

that they need to do their work, notwithstanding that the food is plenty. If the change has been carried to the nitrate stage, the algæ cannot appropriate its results in the absence of light and oxygen. Sometimes there may occur an apparent retrograde movement. If, in the case of a water rich in nitrates, there be an addition of organic matter capable of decomposition, together with the organisms capable of doing the work, they may take the little oxygen that they need from the matter already oxydized, so that an analysis would show a less quantity of nitrates and an increase in the amounts of nitrites or ammonia.

A right understanding of the changes through which the nitrogen goes is essential to a correct interpretation of any water analysis. A strong tendency to stability in the form of the nitrogen is a favorable indication. A state of change is a condition of danger. Large amounts of ammonia or nitrites indicate an incomplete purification, and also a recent contamination. High nitrates indicate the oxidation of the organic matter, but also that there was a previous contamination at some time. If large numbers of bacteria are found, this points to an abundant food supply and to an active state of change.

The chief difficulty in drawing conclusions from the presence of nitrogen lies in its instability and the rapidity with which the changes occur. There is a substance, however, chlorine, that preserves its character through all the changes under which water is modified. Almost all waters have some amount of this substance present, and this is fairly constant for any given locality. When this normal amount is determined by examinations of waters known to be free from pollution, the finding of any excess over this normal in any water may be fairly assumed as indicating organic pollution; and inasmuch as chlorine always forms one of the constituents of sewage, such pollution can be traced to the discharge of a town's sewage into a stream, or the leakage of the contents of a cesspool into a private well.

The interpretation of a biological analysis of a water is a much more difficult matter than that of a chemist's investigation. The science of bacteriology is so new that we do not as yet know just what to look for on the one hand, or, on the other, just how to do it. But our knowledge is being added to faster than one can easily keep pace with it. So far, the only biological analysis that has come into general use, outside of laboratories devoted chiefly to some special scientific investigation, is a quantitative one, being simply an estimation of the number of the bacteria in the water, made from a count of those present in a small volume of it. As has already been said, if large numbers are found, there is indicated a strong activity and rapid change. But what we want to know is much more than this: just what species are at work, what are their life-histories, how they act and react on each other, which ones are detrimental to us and which ones are our helpers, and how we can put them to work.

We have learned how to isolate and study the habits of many of these microbes, but not all of them. We know, in a general way, how our friends, the saprophytic bacteria, or the scavengers that accomplish the work of putrefaction, do their work. The nitrifying organisms, also our friends, we are fairly well acquainted with. By a combination of chemical and biological methods, the expert can often trace a sewage contamination for long distances. Indeed, a microbe or microbes that surely indicate such source of impurity can be found long after the chemist fails to find any trace of such contamination, because of the degree of its dilution in the water. Many of the germs of water-borne diseases, such as typhoid, cholera, and malaria, are known, and have been studied. We also know, in a general way, that the conditions which are favorable to the growth and development of the minute organisms which are our friends are not favorable to

the life of those which are our enemies. But this relationship has not yet been worked out. Then, too, there are no practical tests that can be applied to a water by which the presence of these dangerous germs may with certainty be detected. Perhaps no such tests will ever be found, because of the comparative small number of the enemy that may find their way into the water, and the consequent small probability of catching some of them in taking any sample for examination. Probably we shall have to remain content with indirect methods, from which the presence of these germs may be inferred, rather than to expect the development of any method for their direct detection.

Something more must be said regarding the algæ. Investigators of low water life have been so attracted by the infinitesimal bacteria that these plants have been much neglected. Inasmuch as a once-polluted water cannot be said to be wholly purified until its nitrogen has gone through a complete cycle, until its nitrates have been used by the algæ and these have disappeared through starvation, it seems probable that a knowledge of their habits would enable us to use some of them in correcting bad conditions produced by other forms of life, and, on the other hand, to prevent the appearance of evils that sometimes arise in connection with an excessive growth of some species of these plants themselves.

Mrs. Richards, in her recent book, "Air, Water, and Food," has this to say concerning these plants:

"It is organisms of this class which give tastes and odors to water, and which, if enough were known concerning them, would probably give perfectly trustworthy information as to the past history or source of contamination. The two classes of organisms work in opposite directions, and, so long as food is present for either, life will increase with proportional rapidity. When a ground-water, free from all organic matter, but rich in nitrates, is exposed in an open basin, the rich growth of chlorophyll-bearing algæ follows as a matter of course; later, decay sets in and products of decomposition abound, the air above being the source of a constant supply of spores of all kinds.

"When a house or barn drain empties into a small, sluggish stream, it soon becomes filled with green plants thriving on the ammonia, and it is often possible to trace the source of pollution of a large lake by the line of green amœbina leading to the insignificant ditch.

"The effect of storage of water containing high nitrates in open tanks or reservoirs exposed to the collection of dust will be that spores of chlorophyll-bearing algæ, diatoms, desmids, etc., will soon develop, and will increase as long as the mineral food lasts. Only by protection from dust and light can such water be kept free from unpleasant accumulations of suspended organisms or from disagreeable tastes. Unpolluted surface-waters, on the other hand, improve on storage, as a general rule, if the basin is a clean one. The storage of polluted or clarified water is thus forbidden, since not infrequently the first indication of the pollution of a surface supply is given by the appearance of some member of that richly nitrogenous group of algæ called Cyanophyceæ, or 'blue greens,' from the presence of blue or purple coloring matter along with the yellow-green chlorophyll. Since this group of plants contains from seven to eleven per cent. of nitrogen, while other groups contain only one or two, it is evident that, if it is to flourish, more nitrogenous food must be supplied. This may be derived from fertilized fields, from decay of other vegetable life, as well as from the richer source of direct sewage; but, in any case, the growth of these plants is a sign of abundant food supply, which must be cut off if they are to be starved out, as they must be, unless they are removed while fresh by straining or skimming, for the odor of their decay is so intolerable as to preclude the use of the water. In

some cases the odor accompanying their growth renders the water quite objectionable, and neither natural nor artificial filtration is able to remove it.

"Either natural or artificial basins may have a collection of vegetable matter on the bottom, which slowly decomposes in summer, and, since the bottom water is colder, the resulting ammonia remains till the late fall overturn, when it is brought to the surface, where it favors the growth of diatoms and other cold-water plants. Certain diatoms, as asterionella, cause disagreeable odors. Such basins show the least ammonia in early October and the most in late November.

"In order to make any predictions as to the probable development of this flora and fauna of water, experience and at least a year's watching of any given supply are required, until more is known of the life-history of these forms of life. Nothing is more needed to-day than work along these lines. When may disagreeable tastes and odors be expected? What precaution or measures may be taken in each case to prevent them? These are the questions the water-works superintendent, equally with the consumer, is asking, for the most part vainly, as yet."

In some of the Eastern states these algæ have caused much trouble, especially where water is stored in ponds and small lakes. In our own state there has been some little trouble with tastes and odors, probably due to this cause, where a supply is obtained from a small stream, and, as the state becomes more densely populated and more water plants are built, many of which will be forced to collect and store the water, this is quite likely to increase.

At the present time in Kansas most of our water-works plants secure their supply from ground-water. This comes from that part of the rainfall, some twenty-five to forty per cent., that soaks into the soil and becomes partially or nearly purified by its action. This percolates more or less slowly downward, accordingly as the soil is close or open in texture, until it is stopped by some impervious stratum; then it flows in a sheet in the strata immediately above, which are completely saturated. This motion is a slow one, varying from only a few inches a day in close, clayey soils, to several feet in the open, sandy or gravelly layers, and is one of continuous progression. This sheet-water does not generally lie very deep and is constantly seeking an outlet, where it appears in the shape of springs, or breaks out beneath the beds of rivers or smaller streams. This movement of the underground water is too little realized by the average man who digs a well, and thinks, because the water derived is clear and cool, that it is a safe one for his use. The fact is, that even the isolated well of a farmer's home may harbor much of evil, while town wells as a whole are often much more dangerous than the public supply which may be furnishing a water less palatable or pleasing in appearance. The reasons therefor are not far to seek.

In the soil, which is acting as a filter for the purification of the water that passes through it, much the same agencies are at work in performing the task as were found accompanying the changes in surface-waters. In its top layers, chiefly within the upper twelve inches and rarely extending any deeper than three or four feet, are found the nitrifying bacteria, different in species perhaps from those at work in the adjacent streams, but yet with similar life-histories and producing similar results. In the shape of nitrates they return the nitrogen to the soil, where it can be taken up again by the tiny rootlets of growing plants. If these organisms have time to do their work, if the conditions of temperature, supply of oxygen, etc., are adapted to their need, then the water of the lower layers is freed from its organic nitrogen. An analysis of well-water then shows very little albuminoid or free ammonia and probably no nitrites, while all of the suspended matters that give cloudiness or turbidity to the water have been strained out and left behind in the interstices of the soil. On the other hand if

the conditions are not right, or the passage through the soil is too rapid, the process of change may be interrupted, and the analyst will find the well-water containing evidence of the fact in the amounts of ammonia present. Cracks and seams in the soil, such as are liable to occur in clayey matter in dry times, afford quick passage; and in the case that the surface soil has been polluted in any way, as, for instance, by the throwing out of the discharges from a typhoid patient, such matter may suddenly make its presence in the water known by causing disease in those who use it. Again, at times of heavy and long-continued rains, by the saturation of the upper layers of the soil, the requisite amount of oxygen for the maintenance of the nitrifying bacteria may be much lessened, thus destroying the proper balance between these forms and the putrefactive bacteria which accompany the first stages of organic change. Here, again, the water would show an absence of nitrates and an excess of ammonia.

Generally speaking, the water derived from this underground flow, when filtered through an unpolluted soil, is a safe one; as safe, perhaps, as any that can be gathered. But there are troubles that are peculiar to this method of obtaining a supply, some of which have illustrations in our own state. The water is sometimes impregnated with iron in solution, which, on exposure to the air, becomes precipitated and forms a very light, finely divided mass of floating particles that are very hard to remove by any other means than filtration. The time required for ordinary subsidence is considerable and demands larger reservoir capacity than would otherwise be needed. If this iron-bearing water holds also imperfectly broken-down organic matter in solution, even if it be small in amount, under conditions when the average temperature of the water is somewhat above the normal, and in the presence of sufficient oxygen and the absence of light, there is very likely to develop, with great rapidity, an enormous growth of a species of bacteria called crenothrix. This microscopic plant is a simple cell enclosed in a gelatinous sheath, in which it secretes iron from the water. Though minute, it grows in large tufts and masses that are easily seen by the eye, fastened to the sides of a well or floating free in the water. It seems especially to attach itself to any woodwork, and also grows on the sides of the pipes of the distributing system to such extent as to reduce their effective size and increase the friction. Detached parts of these masses are carried far into the pipe lines and, not finding sufficient food or oxygen, die and decompose, giving a fishy taste and odor to the water and making it unfit for laundry use, because of the staining effect of the iron that was secreted. Where water is obtained through driven wells these organisms cause a deposit of iron, which closes up the fine holes or slits of the points, making frequent renewal necessary. These little plants are not at all uncommon, being found in some degree continuously in waters of this character. In some locations they seem to come and go, making only occasional trouble, while at some points it has been found necessary to abandon a source of supply because of them. The underflow of the Kansas river valley seems to be liable to trouble of this cause.

The storing of this water in tanks and reservoirs open to the light would prevent the development of this organism, but such method would probably lead to a development of the algæ, which find an abundant food supply in the mineralized nitrogen.

The pipe-line system is not free from a large range of both plants and animals, which sometimes develop in such numbers as to cause a good deal of trouble. There is a small animal, barely visible to the eye, that grows in colonies or masses to such an extent as to coat the interior of pipes to the depth of half or three-quarters of an inch. This reduces the sectional area of a six-inch pipe by

fifteen per cent. or more, at the same time presenting a very rough surface to the flow of water. This animal, belonging to the family of the Polyzoa, forms for itself a tough, gelatinous sheath or case, containing its vital parts and having its mouth at the free end, surrounded by a fringe of tentacles, by means of which it draws in its food from the water. The other end of this case is fastened to that of some other individual from which the first had been born through a process of budding; so that a mass of these taken together much resemble moss, so much so that water-works men have given the name of "pipe moss" to these growths. The distribution system may be thus affected throughout its entire length; the smaller mains and the service pipes may be almost clogged; when deprived of sufficient food, the animals will die, their bodies will decompose, and the water drawn from the taps may be discolored and offensive. The pipe system at Lawrence gives some trouble in this way, and the evil is only kept in check by vigorous flushing of the mains during the summer season, causing a waste of water that is a serious tax upon the pumps.

So far as is known, neither of these organisms spoken of above is detrimental to health, though they cause annoyance to both the water-works men and the consumers. It is probably true that a reasonable amount of them, together with other similar organisms, is a benefit to the water of the mains, through maintaining a balance of life. Troubles seem to arise only when the conditions are such that some one form develops to an excessive degree. There are no known remedies which act as a specifics, and much more detailed knowledge of the life habits of the entire class of micro-organisms must be obtained before we can know how to deal with these problems in a satisfactory manner.

Of the last class of waters, those derived from deep wells, there is little to be said in this connection. Generally they are quite free from organic matter, which has all been changed and filtered out by the slow passage through the soil. Because of the solvent action of the water and the gases and acids which it carries, this class is more or less impregnated with mineral salts, sometimes to such an extent as to prohibit use in public supplies. In any case, it is the province of the physician to say whether the waters are fit for use. When designed for use in the arts or in manufacturing, these mineral constituents become of great importance, and the judgment of the chemist will alone control. The chief ingredient present in Kansas waters of this class seems to be salt, and this is encountered over a large part of the state at comparatively small depths below the sheet-water. In the southeast, on the flanks of the Ozark uplift, is found a very good water that serves as a source of public supply. But, as one goes westward from this range of mountains, the artesian water seems to have increasing amounts of mineral matter, though it is probably ample in quantity.

In all that has been said above, it has been assumed that the nitrogen, representing the organic matter, is the polluting material. But, in reality, this is not so. The true cause of most of the trouble to the human system that arises from a water-supply, lies in the admixture with it of something from the waste of human life itself. In all life it seems to be a general principle that each individual cannot exist in surroundings which are filled with the cast-off products of its own life activities. So the germs of water-borne diseases find their way into the water from some individual that is sick with one of them. The dejecta of a typhoid patient, thrown out without proper disinfection, may be washed into a clear, sparkling brook and carried by it to an impounding reservoir, and thence into a town supply, with the result that there is an outbreak of the disease. It does not follow that every one who drinks of the water must become sick, for this depends to some extent on the resistant power of the individual. B[illegible]

true that every case of typhoid comes from a germ that is the seed of the disease, as surely as the acorn must precede an oak, and that the seeds of most cases are carried by drinking water. Marvelously evil results from apparently insignificant causes are not at all uncommon.

Sewage, then, must be considered as the worst element in producing pollution; matter that should by no means be discharged into any stream used for a water-supply, or cast onto any watershed from which such a supply is gathered. Right here comes a serious problem for the sanitarian, the engineer, and the citizen. Water is not only necessary to us in our life processes, but is also one of our chief burden bearers; principally the carrier of our wastes, which it is essential to remove from our environment. There is no more economical and sanitary way of transporting sewage than by means of water flowing in tight sewers. How can we continue this method and still preserve our sources of supply from sewage contamination? Or, if a supply is being polluted by sewage or other cause, how can we remove the polluting matter so as to furnish a safe supply?

The evils to be remedied are by no means new, and efforts have been made for fifty years or more to find a solution of the difficult problems. The density of the population of the older countries of Europe has forced these matters to the front, and more less successful attempts have been made to purify both sewage and water for public supplies, while stringent laws for the protection of streams and the collecting watersheds of reservoirs have been passed and enforced. For many years the chief incentive of those who advanced any new method of sewage treatment seemed to be the desire for a financial gain through the recovery from the sewage of its valuable constituents. Chemists can analyze sewage and figure the value of its nitrogen, phosphorus, etc., at current market prices, thereby estimating the total worth of yearly flow from any town. English estimates were placed at various figures, and the matter was gravely discussed by many of the leading scientists of the day. The value of London sewage was placed at from five million to twenty million dollars per year. A parliamentary commission argued the matter in minute detail, and arrived at a value of four cents a ton as a safe and conservative estimate. These discussions stimulated the inventive mind, with the result that the English government has granted 500 or more patents for the treatment of sewage. In many cases these proprietary methods were actually tried by companies formed to manufacture fertilizers for the open market, and so well were some of these enterprises exploited that they for a time paid the promoters, notwithstanding the fact that the product manufactured had little real value—by no means commensurate with the price asked therefor. These patents involved mainly the method of chemical precipitation, and called often for the use of precipitating agencies that would render the effluent more foul than the sewage itself.

Nor is it strange that the estimates of the fertilizing value of sewage should have turned attention to its utilization on land and the growing of crops through irrigation. Sewage farms sprung up all over England, and their financial success was much talked about, at first. But it was learned gradually that sewage farming with raw sewage and sewage purification were two very different things, that ran opposite rather than parallel; that when worked for the crops the effluent was poor; and when managed to produce a good effluent, the crops would not balance the outlay.

But the idea of financial gain has passed, and the underlying principle now is, as it should be, how to secure a good effluent, and so purify the sewage that it can be turned with safety into a running stream or on to a water-supply's drainage area. If, as a result of the method used, there is any return by way of a

crop or a remarkable product, this is now rightly considered as a happy result, but an entirely secondary one.

Chemical precipitation has been tried with all sorts of substances as precipitants, but securing only a partial purification, which amounts to saying that the effluent is still impure, and, therefore, unsafe. Where such a degree of treatment is wanted as will insure a stream from becoming offensive, and where this is not used for a source of supply, the method may find an application. An electrical treatment results chiefly in the formation of an antiseptic, which is supposed to act directly on germ life, and also of a precipitant set free by the current. It fails of complete action.

Broad irrigation results in a water-logged soil that neither benefits the crop or creates a good effluent.

Intermittent irrigation, rightly managed, and where a sufficient area of suitable open, sandy soil can be obtained, solves the problem quite well. It is, however, of limited application, because of inability to find the right kind of land in necessary quantity within easy reach of many towns. The method has been in use for some years, but the soil's action was not understood, or very imperfectly so, until the state board of health of Massachusetts, through its experiment station, at Lawrence, and the high skill and great ability of its experts there at work, discovered the matter and gave their results to the world. They first brought the slow sand-filtration process into line with exact science, whether applied to sewage treatment or the purification of water.

In this process the water or sewage is slowly filtered through a bed of sand about four feet thick. The filtering material may be of almost any average size of grain, from fine sand to coarse gravel, the rate of filtration and the size of the applied dose being regulated and properly adapted to each grade. In the upper few inches of this bed all of the chemical changes take place by means of the bacteria that there become established. These are very largely of the aerobic type, so that the filter has to be worked intermittently; that is, allowed to drain itself for a time between applications of doses, so as to draw into the sand the air that is needed by the bacteria for their life work. After these bacteria have become well established, which takes some time, the results are excellent. The experimental filters gave effluents in which nearly all of the nitrogen was changed to nitrates, and from which practically all of the organisms that were in the applied water or sewage were excluded; even such bacteria as did appear probably coming from the colonies that had established themselves in the underdrains, and not directly derived from the filter.

It is to be observed that these filters call into action only the aerobic organisms, and that, therefore, in order to attain a maximum efficiency, the first stage of the nitrogen change, due to the action of anaerobic forms, must be brought about before the application of the liquid to the filter; that is, the solids must have been broken up and the organic matters rendered soluble. As a matter of fact, both forms exist in these filters, or, rather, there are forms present that can act in both ways, as anaerobic when the filter is saturated, and as aerobic when working in the presence of oxygen. In case the filters are treating a sewage that comes from a long line of sewers, the first stage has been passed to a large degree by the time the filters are reached, the anaerobics doing their work in the sewers, leaving only a small part of the organic nitrogen to the action of the forms that can adapt themselves. Also in the case of the filtration of river-water, much of the work of this first stage has been already accomplished. Hence, good results can be expected. But if a fresh, raw sewage is to be treated, these filters will give trouble, through the deposit of unbroken-down solids that qu[illegible]

clog the interstices of the sand and prevent the passage of water and the introduction of the needed air. But the method has found successful application on a practical scale for both sewage and water treatment.

Stimulated by the necessities of their environment, the English people have been developing a line of treatment that perhaps more closely follows nature. In 1896 the town of Sutton abandoned chemical precipitation, and installed Mr. Dibdin's scheme of "contact beds." In this the sewage, after a mechanical straining to take out the coarser solids, is run onto a bed of coarse burnt ballast, where it is held for a time, that it may deposit the suspended matter and be worked upon by the anaerobics, thus forming what is called the "contact." The effluent from this "bacteria tank" is then run onto a bed of fine coke-breeze which is operated intermittently, with the intention of getting the action of the aerobics.

The two tanks form a "double-contact" system. They are arranged in duplicate, so that each pair has a period of rest and aeration. From this it seems that reliance is placed on aerobic filters and organisms for combined liquefaction and nitrification in the same bed. While the results are generally good, they are somewhat variable, the reason for which appears to be as follows: The two classes of organisms are mutually antagonistic; an excessive development of one excludes the other, so the true anaerobics do not have opportunity to become well established in the first tank because of its "resting empty" period, while those forms that can adapt themselves are under the necessity of changing their habits every few hours. A further result is that some organic matter is carried over to the second bed without undergoing the stage of change, thus forcing upon that bed some of the work that should have been done in the first. The whole bacterial process is thus frequently disturbed. There is also the screened sludge first taken out to be separately dealt with.

In 1895 Mr. Cameron introduced at Exeter the "septic tank." In this system the raw sewage as it comes from the mains is passed into an underground air- and light-tight tank of such capacity as to hold the flow of twenty-four hours. Both inlet and outlet are below the surface of the water, so that the gases formed do not escape and floating solids are retained. During the twenty-four hours that the sewage has to pass through it is attacked by the anaerobics, which find the conditions very favorable, with the result that all solids of whatever organic nature are broken up and largely dissolved. The heavier mineral matter is intercepted in a grit chamber adjacent to the tank before the admission of sewage. The surface of the tank is covered by a thick, tough scum, which catches and holds the lighter floating solids until they are broken up. On the bottom, there very slowly accumulates a deposit of mineral nature and organic matter that decomposes but slowly. After four years of use this deposit was only four feet thick, representing the total residue of the sewage of a population of 1500 people. The gases formed are inflammable and may be utilized, the pressure being obtained by raising the surface of the contents of the tank by changing the elevation of its outlet, and confining the gas between this and the arched roof.

The effluent from this "septic tank" is run over a weir in a thin sheet to aerate it and then discharged onto filter-beds of coke-breeze, where the nitrifying organisms do their work. Here, then, is a true separation of the two classes of bacteria, and the requirement of regular and continuous action is at least met in the first part of the process.

You will remember, however, that there are three stages of action and three classes of bacteria at work before nitrates are reached. Triple-contact beds, or the addition of a third filter to the septic system, have been suggested as adapted

to these stages, but Mr. Scott-Moncrieff has devised a system that more nearly causes a separation of the different bacteria than could be hoped for from these suggested schemes.

In this the sewage is passed upward through a coarse filter from a shallow chamber underneath, thus forming right conditions for the anaerobics, which seem to be able to deal with all of the solid matter and prevent its accumulation. The overflow from this bed is discharged automatically and continuously onto a series of shallow trays, arranged each over the other, and each receiving its supply from the discharge from the one next above. The automatic device works periodically, so that the materials of the trays are aerated regularly, the sewage trickling down through them and carrying air along with it. There is a rapid formation of nitrites in the two upper trays, but this decreases rapidly in those lower down, and runs out entirely in the eighth and ninth, the last of the series. The lower a tray the more active are the bacteria that produce nitrates, and in the lowest they seem to be the only organisms at work. The entire passage through the nine trays takes only about eight or ten minutes, and the rate of filtration is about one million gallons per acre per twenty-four hours. Mr. Rideal, an English expert, claims that this process gives better nitrate results than any other with which he is acquainted.

In the accounts of this and other English work which I have seen the results are stated in percentages of nitrogen that have been removed, without any statements of the bacterial purity of the effluents secured. This can be inferred to some extent from the results of chemical analyses, and yet must be considered a serious lack to our full understanding of the matters presented.

In attempting to use the Massachusetts methods for the purification of the waters of the region west of the Alleghany mountains, it has been found that they are not applicable. The fine, clayey matters that are carried in suspension in all western rivers—matter that is absent from the New England streams which flow from granite and sandstone hills—clog the pores of sand filters and prevent their use as bacteria beds. Some waters lack organic matter in the form needed to coat sand grains with a gelatinous envelope. Resort must be had to other methods. So there is now going on an active study of what is called the American system, or rapid mechanical filtration. The typhoid death-rate of Louisville, Cincinnati, and Pittsburg, as well as other inland towns, has driven them to elaborate scientific investigations as to the best methods for treating their water-supplies in order to remove the fine silt and render them safe.

The process is not biological, but a combination of chemical and mechanical methods. As worked out at Cincinnati, the river-water was first allowed to settle for some hours in an open reservoir, then pumped into tanks, where it was mixed with a precipitating agent, sulphate of alumina or crude alum, and thence into tanks containing about four feet of sand, through which it passed into a clear well and into the city mains. The precipitate formed by the alum is flocculent, and entangles much of the organic matter from the very start. In the filter the alum is caught by the sand surface, where it forms a gelatinous coating that strains out both the fine silt and all suspended matter, including even such minute things as the bacteria. The bacterial efficiency rarely dropped below ninety-five per cent. and averaged about ninety-nine per cent.; and it was further found that when this was good the character of the effluent was also satisfactory as to clearness and the removal of organic matter.

When the alum layer becomes too thick and offers too much resistance to the flow, the filter is washed by its own filtered water until the collected matter is

driven out. This is done by forcing water from below upwards, at the same time that a mechanical stirring is given the sand.

The rate of filtration used was about 120 million gallons per acre per day, which is 100 times faster than is attained by the slow sand method. An average amount of 1.6 grains per gallon of the alum was used, an amount that is too small to affect the water in any injurious way for domestic use, though slightly increasing the hardness and the tendency to the formation of boiler scale, a point that is considered as being offset by the removal from the raw water of the suspended solids.

One thing that is learned from a study of the investigations made in many localities is that the methods used in one place may not be at all successful at another. Each water or each sewage has its own peculiarities; each location or climate may have its own characteristic fauna and flora among the lower organisms; and all these things must be studied carefully before right means can be used to secure the desired results. Some great general principles must underlie all efforts, so that results elsewhere can be taken as guides, but only as such.

Here in Kansas is a field about which we know very little along these lines. Some geological work has been done, and is now being carried on in a systematic way by the university survey. Some waters have been analyzed by the chemists of the various institutions or reported upon by some one connected with the state board of health when their purity has been questioned. Biologists have done something with the low fauna and flora. But all this has been with no systematic purpose in view, and the time is soon coming when the results of such investigations in our state will be of very great value. At no time in the world's history has there been so wide-spread and general an interest in matters pertaining to public health as the present, and it is hoped that Kansas may put herself in line with the general movement by furthering all investigations that may add to our knowledge, by wise health legislation, and by giving her board of health such authority as will render its efforts effective. This board should have the duty given it to supervise the installation of all public water-supply or sewerage plants, the right to demand that existing plants be conducted in a way not detrimental, and be further charged with the duty and given the money for the study of questions relating to these things that may arise.

III. BIOLOGY.

SOME DIATOMACEÆ OF KANSAS.

BY GEO. H CURTIS, MCPHERSON.

DIATOMACEÆ OF GAGE'S POND, TOPEKA, AND OF SILVER LAKE.

Read before the Academy, at McPherson, December 29, 1899.

Although the Diatomaceæ of the eastern United States have been pretty thoroughly investigated by several competent observers, I believe that little is known as to what forms exist in the West. With the exception of Thomas and Chase's catalogue of the Diatomaceæ of Lake Michigan, which embraces 34 genera and 214 species, and my own catalogue of the Cincinnati forms, 42 genera and 972 species, there are no investigations of western or central-western forms known to me.

Under these circumstances, perhaps a short paper upon Kansas forms may possess sufficient interest to justify reading it.

In company with Mr. Frank Patrick, I paid a visit to Gage's pond, in the western suburbs of Topeka, about the middle of October. It was dug by Mr. Gage a number of years ago as a fish-pond and stoned up. I did not think of estimating its dimensions while there, but is perhaps 150 feet long by 50 feet wide, and two or three feet deep. Our object in visiting it is was to ascertain if it contained diatomaceous material; and, while there, I made a gathering which, when cleaned up a few days afterward, yielded some very interesting slides, and some *Naviculæ* not previously met with elsewhere.

The most abundant form in the gathering was *Epithemia gibba*, both the long and the short varieties. The most common *Navicula* was *radiosa*. *Cymbella stomatophora* of several sizes was also common; and *Amphipleura pellucida*, a rare form, more than usually abundant. My gathering was made on the east side, about midway; and it was rather curious that there was no *Amphipleura* in Mr. Patrick's gathering, made only a short distance away at the south end, or from the under sides of the leaves of the water-lilies, of which many were growing in the pond. *Synedra ulna*, var. *longissima*, was abundant, especially in Mr. Patrick's gathering. *Gomphonema* was rather rare. There were a considerable number of large, somewhat curved, sponge spicules. *Navicula cuspidata* was a prominent form—both the long and the short varieties. *Cymbella*, usually one of the most abundant forms in any gathering East, was very scarce at Gage's pond, as well as *Gomphonema*.

The most noticeable thing about the gathering was the remarkable predominance of the rare form, *Epithemia gibba*, of which there were, in a field taken at random, under a quarter-inch objective, no less than seventy-eight individuals, as compared to nine *Cymbellæ*, four *Naviculæ*, thirteen *Synedræ*, and four *Denticulæ*—almost three times as many as all the other forms together.

As some may not have had experience with the microscope, I would say that the field of view mentioned above was round, and one-fiftieth of an inch in diameter. This will convey some idea of the exceedingly minute size of these diatoms: that 108 of them, as mentioned above, could, without any crowding whatever, be placed in a circle of that size.

To give an idea of the rarity of *Epithemia gibba* at other places, I may say that, in the forty-four slides from which my catalogue of the Cincinnati Diatomaceæ was drawn up, representing about thirty different gatherings, this diatom is found in only two of them. In a very remarkable gathering I made from the Fox river, at Elgin, Ill., a half-inch mount of which contained ninety-four recognized species, only two *Epithemia gibba* were observed, and in one from a pond in Oakwood park, Elgin, none; nor were there any in fine gatherings made at places so widely scattered and generally representative of the West and South as Lake Geneva, Wis., Hailey's Springs, Idaho, or Calera, Ala. There were none in a gathering I made from the Chicago water-supply, though it is catalogued in Thomas and Chase's Diatomaceæ of Lake Michigan, from which the city water-supply is derived. Two fine gatherings made in northeastern Ohio, near Ashtabula, contained no *Epithemia gibba*. A gathering made early in October from the fountain basin on Twelfth street, two or three blocks southwest of the capitol, in Topeka, contained hardly anything else but this *Epithemia;* so that its abundance here seems to be a remarkable peculiarity of this locality, depending, perhaps, on some constituent of the water-supply unusually favorable to it. If so, it must, I imagine, be derived from the Republican branch of the river, as a gathering I made from the Blue at Beatrice, Neb., last year, contained none of this diatom.

In connection with *Amphipleura pellucida*, mentioned above, it is not only very rare, but is placed at the end of Möller's test plate as the most difficult test object known to microscopists, and is stated in scientific text-books to be the smallest regularly organized thing known. The figure I give (fig. 30, pl. III) is not very satisfactory, but may serve to convey an idea of it. Of course, the delicate markings referred to below are not visible at 775 diameters, and the lines across the middle are merely a very coarse imitation of them, to show their direction, etc.

Mr. Patrick informed me that he very carefully examined the alga the *Amphipleura* was growing on and found it to be *Cladaphora fracta* Kg., which I believe only grew over a small space on the east and north walls, a fact very interesting, as showing that it is probably parasitic on this alga, and only found in connection with it, something not before observed, so far as known to me. This would account for its not being found under the lily-pads, or at the south end, where this alga did not grow. The rarity of this diatom may be due to the fact that this alga does not grow everywhere.

As possessing possible interest, I may say that I once measured *Amphipleura pellucida* by a Rogers stage micrometer, and found it not quite one two-hundredths of an inch in length. The smallest grains of ordinary sand which can be picked up with a pair of watchmaker's tweezers and arranged as close together as possible under a magnifying glass go only sixty-four to an inch, so that the length of this diatom is only a little over one-quarter of the diameter of one of the finest grains of sand; yet in this short length it is marked with 340 of the finest and most regular lines ever seen ruled across it, and each line apparently composed of rows of beads. I counted these lines on an excellent photograph of it, by Doctor Detmers. A list of the genera and species found at Gage's pond is as follows:

Achnanthes minutissima.
Amphipleura pellucida.
Amphora libyca.
Amphora ovalis.
Cocconema australicum.
Cocconema cistula.
Cocconema lanceolatum.
Cocconema mexicanum.
Cocconema (a large unknown, perhaps new).

Cymatopleura elliptica.
Cymatopleura solea (both long and short).
Cymbella gastroides.
Cymbella stomatophora.
Cymbella turgidula.
Denticula elegans.
Denticula tenuis.
Denticula thermalis.
Diatoma tenue.
Encyonema lunula.
Encyonema turgidum.
Epithemia gibba.
Epithemia gibba, var. ventricosum.
Epithemia sorex, short form.
Eunotia gracilis.
Eunotia lunaris.
Eunotia lunula.
Fragellaria intermedia.
Fragellaria mutabilis.
Gomphonema abbreviatum.
Gomphonema affine.
Gomphonema affinis.
Gomphonema angustatum.
Gomphonema angustatum, var. intermedia.
Gomphonema angustatum, var. producta, Grün.
Gomphonema commutatum.
Gomphonema constrictum.
Gomphonema gracile, forma parva.
Gomphonema lagenula Kg.
Gomphonema mexicanum Grün.
Gomphonema obtusatum.
Gomphonema olivaceum.
Gomphonema parvulum.
Gomphonema parvulum, var. subcapitata.
Melosira lyrata, var. (?).
Meridion circulare.
Navicula acrospheria, var. (?).
Navicula arenaria Donk.
Navicula bacilliformis.
Navicula biceps Ehr.
Navicula brebissoni.
Navicula cuspidata.
Navicula decurrens (Pinn.)
Navicula divergens, forma minor.
Navicula elliptica, var. oblongella (fig. 24, pl. III).
Navicula flanatica.
Navicula gibba (Pinn.)
Navicula hemiptera.
Navicula interrupta.
Navicula lanceolata.
Navicula lanceolata, var. much smaller.
Navicula mesolepta.
Navicula nodosa, var.
Navicula (No. 15, Schmidt's Atlas, pl. 44).
Navicula (No. 44, Schmidt's Atlas, pl. 45).
Navicula (No. 45, Schmidt's Atlas, pl. 44).
Navicula (No. 55, Schmidt's Atlas, pl. 7, with some reserve).
Navicula oculata.
Navicula oblonga.
Navicula peregrina.
Navicula producta.
Navicula pseudobacillum.
Navicula radians.
Navicula radiosa.
Navicula radiosa, var. acuta.
Navicula retusa.
Navicula rhyncocephala.
Navicula rostellata.
Navicula (small, elliptical, coarsely marked, fig. 10, pl. II).
Navicula schumanniana.
Navicula stauroneiformis.
Navicula stauroptera.
Navicula stomatophora Grün.
Navicula subinflata (fig. 23, pl. III).
Navicula tabellaria Grün.
Navicula trinodis.
Navicula ventricosa, forma minuta.
Navicula viridis (Pinn.)
Navicula viridula Kg., forma minor.
Nitzschia frustulum.
Nitzschia sigma.
Nitzschia (small, unknown, coarse markings).
Pleurosigma spencerii.
Stauroneis anceps.
Stauroneis phœnicenteron.
Stauroneis (unknown, small).
Surirella apiculata.
Surirella molleriana.
Surirella ovata.
Surirella ovata, var.
Surirella panduriformis.

Surirella suevica.
Synedra crotonensis.
Synedra danica.
Synedra familiaris.
Synedra pulchella.
Synedra superba.
Synedra ulna, var. longissima.
Synedra ulna, var. vitrea.

Total genera, 21; species, 108.

Many more might undoubtedly be discovered by devoting time to the more thorough examination of the slides, as I never sit down to them without finding something new. As sixty species is a fair average for the best gatherings, it will be seen that this at Gage's pond was unusually good.

A gathering made at Silver Lake, twelve miles west of Topeka, yielded much the same forms, except that in a half-inch mount of it only two *Epithemia gibba* were observed, and with the following additions:

Achnanthes hudsonis.
Achnanthes exilis.
Achnanthes lanceolatum.
Cocconema cistula (a new variety).
Cyclotella comta.
Cyclotella meneghiniana.
Cymatopleura apiculata.
Encyonema triangulum.
Fragellaria turgens.
Gomphonema affine, forma major.
Gomphonema gracile.
Melosira crenulata.
Melosira varians.
Navicula ambigua.
Navicula ampliata.
Navicula confervacea, var. peregrina, Grün. (fig. 17, pl. III).
Navicula lanceolatum.
Navicula sphærophorum.
Nitzschia dissipata.
Nitzschia hungarica.
Nitzschia paradoxa.
Nitzschia sigmoidea.
Nitzschia tryblionella, forma minor.
Nitzschia tryblionella, forma densus striatæ.
Nitzschia tryblionella, var. victoriæ.
Pleurosigma eximium.
Pleurosigma hippocampus (?).
Pleurosigma delicatulum.
Surirella intermedia.

One additional genus, *Cyclotella*, and twenty-nine species.

DIATOMACEÆ OF RENO COUNTY, KANSAS.

(Read before the Academy, at Topeka, December 28, 1900.)

Mr. S. G. Mead made a gathering last fall at Medora, Reno county, which he said he did not clean up well and he wished me to try it. On account of much flocculent matter, which seems to be a silicate which the diatoms grow in, also much fine sand of the same specific gravity as the diatoms, as well as the vast difference in the size and weight of the latter, some being among the largest and some among the smallest forms known, it was the most difficult material to deal with, by either subsidence or flowing, that I have ever met with; and the difficulties were much increased by there being so little of it to work upon—only a thin skin of black mud, about half a thimbleful, at the bottom of a tumbler.

I however succeded in getting four or five fair slides, which conclusively proved it to be a very rich material, and that the forms of the western part of the state, as compared with the eastern, such as those of Gage's pond and Silver Lake, were unexpectedly large and interesting.

It had for some time been an opinion of mine, formed from a number of gatherings made around Salina and McPherson, that the central and western parts of the state were decidedly poor, if not altogether deficient in large forms of any kind. Still, about the first thing seen after placing the Medora slides under the microscope was one of the very largest *Nitzschiæ*, long, and a little curved, perhaps *spectabilis*, or new (?), (see fig. 14, pl. II) and large enough to be easily re-

solvable by a 1-4, central light—something very exceptional in that genus, which are usually so finely marked as to be among our most difficult test objects, and usually unresolvable by almost any power and central light.

There was a great abundance of fine *Surirellæ*, mostly *tenera*, *splendida*, or varieties, which are among the largest diatoms in that genus. Also, another much longer but narrow, like fig. 8 of Schmidt's Atlas, pl. XXIII, one of the largest *Surirellæ*, and a very unusual form, not found at Cincinnati, Gage's pond, or Silver Lake. (See fig. 13, pl. II.)

The smaller forms, too, were very numerous and interesting, and included many, especially several small, oval *Naviculæ*, which could not be recognized from any of the authorities at hand, and were perhaps new. As is usual, *Navicula* was the most abundant form as to species, though by no means as to individuals.

One of the features of these Medora slides was the almost entire absence of *Gomphonema*, as noticed also in eastern Kansas—one of the most abundant forms everywhere else, and so abundant at Cincinnati that many slides of the forty-four mounted there contain hardly anything else; but they were so scarce at Medora that I was inclined for some time to think them altogether absent; though I eventually succeeded in finding several in the five slides, almost all of different species.

Melosira, a very abundant genus at Cincinnati, was altogether absent at Medora. *Cocconeis*, a very common form, especially *pediculus*, was not observed in the Medora slides nor at Gage's pond nor Silver Lake, though there was one in the stomach of the little fish caught at Belvidere. Only one individual of *Meridion* was met with, and only one *Synedra*, which at Cincinnati was the second most abundant form, *Nitzschia* being first.

There are usually *Pleurosigmæ* in almost every gathering made anywhere; and there were plenty at Belvidere, not far away; but, very curiously, not a single one could be found in these Medora slides.

Cymbella is usually a very abundant form everywhere, almost as much so as *Gomphonema*, it being present at Cincinnati in the proportion of eighty to eighty-eight of the latter: but it was so rare at Medora as to be seldom seen. *Eunotiæ*, common at Cincinnati, were entirely absent in Kansas, none having been found at Gage's pond, Silver Lake, or Medora.

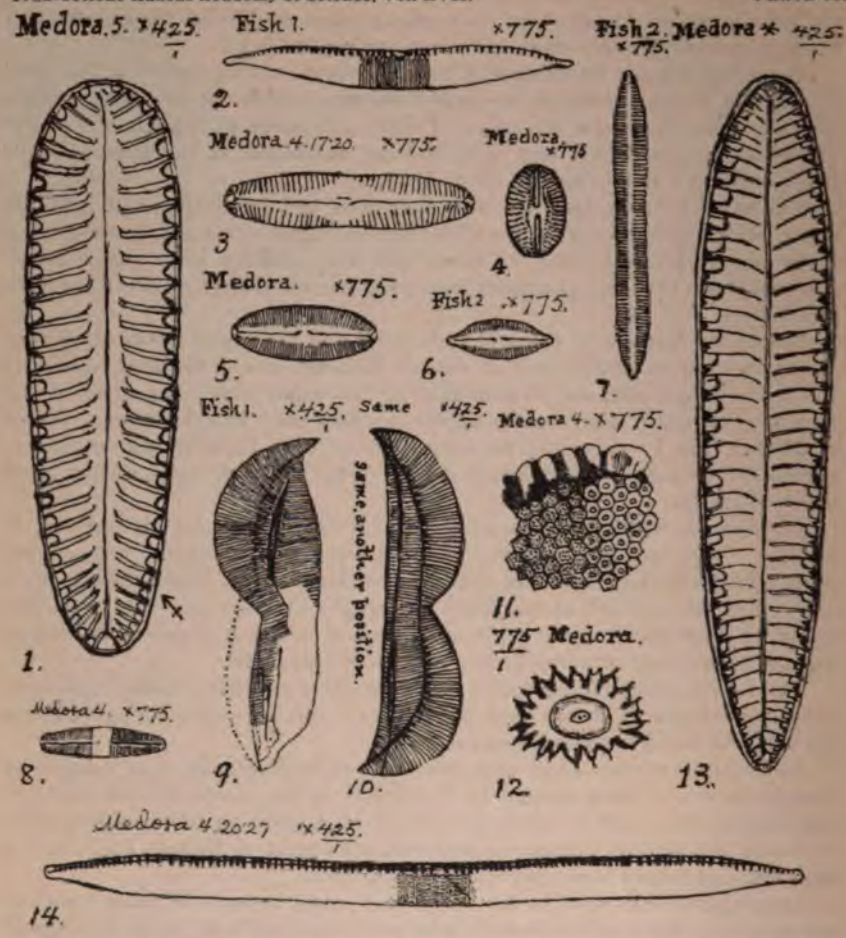
I know not how to account for the almost entire absence of these forms so universally abundant in the Eastern states and the central West, unless we suppose it to be due to the only abnormal condition present, so far as known to me; that is, to salt or alkali, especially the latter, which whitens the surface around the marshes in that section whenever the water goes down.

There are several curious unrecognizable pieces found in the five slides. One of them resembled part of a shell, apparently. The central half rose up in a boss or swelling, surrounded by a flat surface covered with irregular wavy lines.

There were a good many cylindrical pieces, appearing under a 1-10 to be about an inch or an inch and a quarter long, and an eighth of an inch or a little more in diameter; very rough outside. No fresh-water sponge spicules were seen, which I should otherwise have been inclined to connect them with, and it was impossible to tell just what they were.

A second piece (fig. 11, plate II), a round, saucer-shaped disk, I at first thought a *Coscinodiscus*, common in salt water, but of which there is only one represented in fresh water, *C. lacustris*, of which one individual was found in the forty-four Cincinnati slides; but which is very rare. The central part was reticulated in hexagons like honeycomb. It was so dishing I could not get enough

Transactions Kansas Academy of Science, Vol. XVII. PLATE II.



of it in focus at a time to make a very satisfactory drawing of it; but I have done the best I could.

The upper edge seems to be hidden under some kind of trash, which, if it were away, might reveal the border, which would establish whether it was *C. lacustris* or not; still, I have little doubt that it is, or of that family. When best adjusted, the hexagons appeared somewhat dark, with a round, white dot in the center of each, as on the right of the figure; but, by adjusting up a very little, the white circles disappeared, and were replaced by small, black dots, like those of *Triceratium favus*, as seen on the left.

One of the most curious things found had no particular color beyond a slight smoky tint, and the central part was raised up into a sort of boss or umbo, in the center of which there was a rather dark-blue spot, in which were usually two grains of something like black sand, though sometimes only one. Some are much more regular in outline, as well as larger than the one I made the drawing from (fig. 12, pl. II); and they are moderately plentiful, say two to five in a half-

inch mount. The points are each protected by a long, sharp thorn of a darker color, inclined to black.

Mr. Frank Patrick, of Topeka, suggested its being part of a fresh-water sponge spicule, which seems very probable, as it would explain its having survived the action of boiling nitric acid, otherwise difficult to account for. In this view of the case, we may suppose that it formed the ends or caps to the cylindrical pieces mentioned above, and part of the birotulate spicule of some species of *Myenia*.

I was unable to get enough of it in focus at one time to make a satisfactory drawing of the right-hand side of the large *Surirella* (fig. 1, pl. II), as every slight change of adjustment caused a different appearance of it. The alea, however, seemed to be like those of *S. tenera*, and the contour is right. It is nearly of the same size at each end, and I was unable to find anything like the unusual wide lower third of it in any of my books of reference, and it is, possibly, a deformity. It was finally decided to be a *S. robusta* of Ehrenberg. The *Surirellæ* and the *Nitzschiæ* (fig. 14, pl. II), were drawn at 425 to 1, as I did not have room for them larger.

Not to make this too long and tedious, I will say that the collection of diatoms

found at Medora is as follows, so far as recognized; there is some doubt in the case of a few of them, indicated by an interrogation point (?):

Achnanthes biasolettiana Grün.
Achnanthes exigua.
Achnanthes hudsonis.
Achnanthes lanceolata.
Achnanthes minutissima Kg., forma curta.
Achnanthes trinodis.
Cocconema cymbiforme.
Cymbella amphicephala.
Cymbella anglica.
Cymbella naviculiformis.
Cymbella (No. 52 of Schmidt's No. 9, not named).
Cymbella pusilla of Grünow.
Denticula tenuis.
Encyonema (large, like Schmidt's Atlas, pl. 71, fig. 18).
Encyonema lunula.
Encyonema (No. 61 of Schmidt's Atlas, pl. 10).
Encyonema ventricosum.
Epithemia gibba.
Epithemia gibba, var. ventricosum.
Epithemia gibberula.
Fragellaria elliptica, forma minor.
Fragellaria intermedia.
Fragellaria mutabilis.
Gomphonema affine.
Gomphonema angustatum.
Gomphonema auritum A. Braun.
Gomphonema clavatum.
Gomphonema insigne.
Gomphonema lagenula.
Gomphonema monatum, var. subclavatum.
Gomphonema sarcophagum.
Meridion circulare.
Navicula acrospheria.
Navicula affinis.
Navicula alternans.
Navicula amphirhynchus Ehr.
Navicula ampliata.
Navicula arenaria Donk.
Navicula bacillum.
Navicula bacillum, forma minor.
Navicula bicapitata Lag., var. hybrida (fig. 3, pl. II).
Navicula borealis, (type form).
Navicula borealis, var. (No. 16 of Schmidt's Atlas, fig. 45.)
Navicula borealis, var. (larger and more coarsely marked).
Navicula brebissoni.
Navicula columnaris.
Navicula commutata.
Navicula confervacea Kg., var. hungarica (fig. 5, pl. II).
Navicula conspicua.
Navicula cryptocephala.
Navicula cuspidata.
Navicula dicephala W. S.
Navicula dicephala W. S., forma minor, Grün.
Navicula dilatata.
Navicula dirhynchus.
Navicula dubia Greg.
Navicula elliptica.
Navicula elliptica, var. minuta Grün. (fig. 4, pl. II).
Navicula firma Kg.
Navicula firma, var. subampliata.
Navicula fontinalis Grün.
Navicula gibba (Pinn.)
Navicula inflata.
Navicula interrupta (Pinn.)
Navicula lanceolata Kg.
Navicula leptogongyla Kg.
Navicula linearis.
Navicula macra, var. ? (fig. 8, pl. II).
Navicula major (Pinn.), ex re Grün.
Navicula mesostyla (Pinn.) Ehr.
Navicula nobilis Ehr., var. (No. 3 of Schmidt's Atlas, pl. 43).
Navicula (No. 22 of Sch., pl. 49, not named).
Navicula (No. 40 of Sch., pl. 49, not named).
Navicula (No. 44 of Sch., pl. 44, not named).
Navicula (No. 47 of Sch., pl. 50, not named).
Navicula (No. 75 of Sch., pl. 45, not named).
Navicula obtusata W. S.
Navicula producta W. S.
Navicula pseudobacillum.
Navicula pupula (?).
Navicula rhynchocephala.
Navicula rupestris (Pinn.) Hautsch.
Navicula stauroparva.

Navicula stauroptera.
Navicula subinflata.
Navicula tenella Breb.
Navicula tuscula.
Navicula undulata.
Navicula, unknown (figs. 16 and 23, pl. III).
Navicula veneta.
Navicula viridis A. S.
Nitzschia amphioxys.
Nitzschia apiculata.
Nitzschia communis.
Nitzschia lanceolata.
Nitzschia palea.
Nitzschia paradoxa Grün.
Nitzschia spectabilis.
Stauroneis phœnicenteron.
Surirella apiculata.
Surirella delicatissima of Lewis.
Surirella (like 64 of Sch., fig. 23).
Surirella (like saxonica, but very coarsely marked).
Surirella molleriana, var.
Surirella nobilis Grün.
Surirella robusta Ehr. (fig. 1, pl. II).
Surirella splendida.
Surirella tenera Greg.
Surirella tenera, var. splendidula.
Surirella tenera, var. nervosa, A. S.
Synedra lanceolata.

Total genera, 14; species, 111.

THE FOOD OF FISH IN CENTRAL KANSAS.

Read before the Academy, at Topeka, December 29, 1900.

Mr. S. G. Mead, of McPherson, gave me a small fish about two inches long, which he caught at Belvidere, Kiowa county, Kansas, last fall. It was apparently a young perch, to judge from its shape and the dark bands along its sides. Having a curiosity to know what its food had consisted of, I undertook a microscopical examination of the contents of the digestive tract; but the difficulty of arriving at satisfactory results was much increased by the carbolic acid and oil the fish had been preserved in, which interfered very much with the proper action of chemicals, especially acids, and did not seem to yield well to either soap, benzine, or alcohol.

The investigation was, therefore, not altogether so satisfactory as I could wish; but was sufficiently so to establish the main points, and to prove that their food consists very largely of diatoms, mostly *Naviculæ*, of the *radiosa* type; of which I was able to make a very satisfactory examination, to be referred to again further on. There were also many starch grains, shown by the polariscope to be those of the potato, and about as many, perhaps, which were smaller, and possibly derived from bits of bread. There were also a number of green bodies of roundish contour, which were without much doubt desmids. They had been too long subjected to the action of the gastric secretions for the species to be exactly made out, but they were probably *Cosmariums* of some sort; and their numbers were apparently too small for them to have formed a very important part of the fish's diet. About a dozen grains of corn-smut were met with, all in one place.

There was a very considerable quantity of white sand in the stomach and intestines, hardly any field of view in the microscope one-fiftieth of an inch in diameter being without a number of grains of it. They were generally of about the same size as ordinary river sand, and polarized equally well. In one field of the size mentioned above there were thirteen grains of it, in another nine, and in a third five, of three taken at random. It may be possible, though hardly probable, that this sand was swallowed accidentally. It is, however, far more likely that it was swallowed designedly, to aid the process of digestion, as is the case with birds; and the size of these sand grains would, considering the difference in size of the two creatures, apparently bear a just proportion to the little stones swallowed for this purpose by fowls.

They may also have been swallowed to act by their weight as ballast to counteract the natural buoyancy of the body, like the stones of considerable size usually found in the stomachs of alligators, and which are supposed to have been swallowed to assist them in remaining at the bottom.

The fact that there were no grains of black sand among it, which does not polarize, would rather seem to lend support to the digestive theory; inasmuch as white sand, being composed of quartz, or almost pure silica, and hard enough to scratch glass, would naturally be selected by them to assist in the grinding or trituration of their food, rather than the much softer black sand.

There was observed at one place an agglomeration of small, round grains, quite smooth outside, like very small fish eggs, which they perhaps were, or spores of some small toadstool or other fungus. They were transparent, and not much over one-quarter the size of the grains of sand mentioned above.

A great quantity of some dark-colored substance, finely comminuted and apparently of animal origin, was found, perhaps the remains of worms or meat of some kind; but, although most carefully sought for, there were no feet, wings, scales of lepidoptera, parts of insects, crustaceans, or muscular fibers of any sort among it, such as would have been likely to have survived the digestive process and given a clew to its character.

As we may see from the smallness and degree of convexity of their eyes that fish must be capable of seeing things infinitely smaller than would be visible to the human eye, this matter was perhaps composed of minute particles of both animal and vegetable origin which the fish met with and swallowed as it swam about, and which were perhaps too small to preserve any definite recognizable character, especially after passing through the stomach.

Their principal food, though, to judge from the great numbers of frustules of different kinds found in the stomach and intestines, were diatoms, the outer shells of which, being composed of almost pure silica, are well-nigh indestructible by the digestive process, fire, or the strongest acids.

After preparing the diatoms for examination under the microscope, it was seen that the greater part of these small organisms in view were *Naviculæ* of small size, of the type known as *radiosa*, *arenaria*, etc., of two or three sizes, or of the *lanceolata* form, with divergent striæ, such as are figured in Schmidt's Atlas of the Diatomaceae (plate 47) or varieties of that type. (See fig. 26, pl. III.) Some were much larger and some smaller than the figure, but mostly of the same general type.

Gomphonema was, as usual in Kansas gatherings, very rare, though four or five species were met with. *Cymbella*, also one of the commonest forms anywhere East, was equally scarce; and I had about concluded that none except small forms were present, when I unexpectedly came across an *Amphiprora* of the largest size (fig. 9, pl. II), and of a decidedly rare variety, not found in the forty-four Cincinnati slides. The individuals of this family are among the largest diatoms; and they were remarkably abundant, as if there was a savor or a large body of nourishment in them which had especially appealed to the fish's taste. Figure 10, plate II, is another individual in a different position.

A noticeable thing was not only the abundance of this large and rare *Amphiprora* not found at Gage's pond or Silver Lake, but the remarkably large number of fine *Pleurosigmæ*, mostly *spencerii* or varieties, every field containing at least one and often several. The figure I give of it (No. 18, pl. III) would have been better if drawn on a larger scale; but I did not have room on the plate for one larger.

An unusually large form of *Amphora lineata*, not found at Gage's pond,

Silver Lake, or in the forty-four slides of Cincinnati diatoms, was quite abundant. Only one *Navicula* of the *rhomboides* type was seen, and that was a variety, the *Colletonema vulgare* of Thwaites. *Stauroneis phœnicenteron*, one of the few distinctively fresh-water forms said to be found everywhere, was not met with.

Epithemia gibba, so remarkably abundant at Topeka, was present, but rather uncommon. Of the three or four species of *Nitzschiæ*, only one seemed to be of common variety, and one of them, *Nitzschia sigma*, is catalogued by different authorities as a marine form. A most remarkable thing was that not a single *Surirella* of any kind was seen in the three slides mounted. As they are one of the most abundant forms everywhere, and there being plenty near at Medora, we must either conclude that there were none where the fish lived, or that they possessed some poisonous or other undesirable qualities which caused him to reject them.

One of the most remarkable things found was the *Mastagloia* (fig. 20, pl. III). The genus is almost exclusively marine or brackish, and only one of the two species are ever found in fresh water, and they are excessively rare. This one, *M. lacustris*, was not found at Cincinnati; though an allied species, *M. lanceolata*, was recognized there with some slight reserve. It is also catalogued by Thomas and Chase, but none of either was found at Gage's pond or Silver Lake.

Fig. 7, pl. II, seems to be what Grünow calls *Nitzschia apiculata*, though the blank line down the center and the absence of alea seem to identify with *Synedra*.

To give an idea of the relative proportions of the genera present in a field of view one-fiftieth of an inch in diameter, selected merely because it had an *Amphiprora* in it, so as to include that, there were the one *Amphiprora*, one *Amphora*, one *Cymbella*, two *Nitzschiæ*, three *Pleurosigmæ*, and thirty-four *Naviculæ*.

The genera and species, so far as observed, were as follows:

Amphiprora conspicua (?), (perhaps columetica?).
Amphiprora paludosa W. S., said to be British (fig. 9, pl. II).
Amphora cymbifera Greg.
Amphora lineata (fig. 15, pl. III).
Amphora (No. 18, Schmidt's Atlas, pl. 39).
Cocconeis pediculus.
Cocconema australicum A. S.
Cocconema cistula.
Cocconema helveticum.
Cocconema hungaricum.
Cocconema lanceolatum.
Cocconema mexicanum.
Cyclotella rotula.
Cyclotella (a small unknown).
Cymbella affinis.
Cymbella gastroides.
Cymbella helvetica.
Cymbella kamchatica Grün.
Cymbella minuscula Grün.
Cymbella (No. 40 of Sch. 9, not named).
Cymbella stomatophora.
Cymbella tumidula.
Cymbella turgidula.
Cymbella (two small unknown).
Denticula splendens.
Encyonema lunula.
Epithemia gibba.
Epithemia gibba, var. ventricosum.
Epithemia gibberula.
Epithemia (like musculus, but ends not so sharp).
Epithemia (uncertain, fig. 21, pl. III).
Epithemia zebra.
Gomphonema abbreviatum.
Gomphonema angustatum, var. intermedia.
Gomphonema capitatum.
Gomphonema clavatum.
Gomphonema commutatum.
Gomphonema commutatum, var. subramosum.
Gomphonema intricatum, var. pumila.
Gomphonema olivaceum.

Gomphonema olivaceum, var. vulgaris.
Gomphonema ventricosum.
Homœocladia sigmoidea.
Mastagloia smithii Thw., var. lacustris, Grün. (fig. 20, pl. III).
Navicula amphiceros? (fig. 6, pl. II).
Navicula bacillum.
Navicula borealis (var. small, with nine coarse striæ).
Navicula brebissonii.
Navicula cymbula Donk.
Navicula elliptica.
Navicula elliptica, var. oblongella (like fig. 24, pl. III).
Navicula gracilis (Kg.) Grün.
Navicula gregaria Donk.
Navicula interrupta (Pinn.) S. W.
Navicula lanceolata (Kg.), var.
Navicula leptogongyla.
Navicula longa.
Navicula macra.
Navicula mutica, var. goeppertiana.
Navicula (large, coarsely marked, lanceolate, unknown).
Navicula (No.11 of Schmidt's 47, not named).
Navicula (No. 13 of same, not named).
Navicula (No. 15 of same, not named).
Navicula (No. 22 of Schmidt's 44, not named).
Navicula (No. 23 of Schmidt's 44, but rather coarser).
Navicula (No. 32 of Schmidt's 44, with some reserve).
Navicula obtusata.
Navicula pumila Grün.
Navicula radiosa Kg.
Navicula radiosa, var. acuta.
Navicula rhomboides, var. (Colletonema vulgare Thw.)
Navicula rupestris (Pinn.) Grün.
Navicula smithii (?).
Navicula subcapitata, var. stauroneiformis (fig. 22, pl. III).
Navicula subinflata (fig. 25, pl. III).
Navicula stauroptera.
Navicula stauroptera parva Grün.
Navicula tabellaria.
Navicula tenella.
Navicula (unknown, perhaps naveana?).
Nitzschia amphioxys.
Nitzschia amphioxys, var. vivax (fig. 2, pl. II).
Nitzschia angustata.
Nitzschia frustulum.
Nitzschia heufleriana.
Nitzschia hungaricum.
Nitzschia sigma.
Nitzschia stagnarum Rabh.
Nitzschia triblionella.
Pleurosigma gracilentum Rabh.
Pleurosigma spencerii (fig. 18, pl. III).
Pleurosigma sciotense.
Pleurosigma kutzinghii.
Synedra acus.
Synedra crotonensis.
Synedra danica.
Synedra familiaris.
Synedra (an end of, perhaps, Chaseii?).
Synedra pulchella, forma major.
Synedra ulna.

Total genera, 16; species, 100.

LIST OF PLANTS IN MY FLORIDA HERBARIUM. PART II.

BY A. S. HITCHCOCK, MANHATTAN.

Read (by title) before the Academy, at Topeka, December 28, 1900.

[The first part of this paper will be found in the Transactions of the Kansas Academy of Science, XVI, p. 108. Since then a collection has been received from Mr. John Hendley Barnhart, of Tarrytown, N. Y. They are from Pasco county and vicinity, and are indicated by the initial B. These, with a few others, are included in a supplemental list. A collection made by myself in Lee county during the summer of 1900 is listed in a separate paper. The plants have not been submitted to specialists, yet most of the specimens of Curtiss, Nash, etc., have been; and the aim has been to segregate the specimens into the proper groups. There are still many uncertainties among the genera *Panicum*, *Paspalum*, *Rhynchospora*, and other complex groups.]

For the sake of brevity, the collector's name is represented by his initial in most cases. These initials are:

C = Mr. A. H. Curtiss, sets of North American plants.

N = Mr. Geo. V. Nash, sets of Florida plants.

R = Prof. P. H. Rolfs, Lake City, Florida Agricultural College, who has given me much help in the work.

W = Mr. H. J. Webber, Department of Agriculture, Washington, for several years stationed at Eustis.

S = Mr. J. H. Simpson, plants distributed by the Department of Agriculture. Many of these are without number or locality other than "Florida," but are from the region south of Tampa.

P = Plants from the Keys recently distributed by Messrs. Pollard, Collins, and Morris.

H = My own collection. The first series was obtained in June and July of 1894 at Eustis and vicinity. While here Messrs. Webber and Swingle gave me much valuable assistance. The second series was obtained in the winter of 1895–'96, along the east coast, from Palm Beach to Cocoanutgrove, on Biscayne Bay. Under the latter locality are included collections from Cape Florida. A few labeled East Florida were collected at various places on the way down, chiefly at Jacksonville and St. Augustine. The third series was obtained during the summer of 1898 on a trip on foot from Monticello to Bayport, following the line of railroad to Live Oak, Branford, Archer, Dunellon, Fitzgerald, and Brooksville. The plants collected on this trip are labeled by counties. Those labeled Columbia county were collected in the southern part, and so are distinguished from those collected at Lake City.

HAEMADORACEAE.

1257. **Lachnanthes tinctoria,** Ell. De Funiak, R 238; Lake City, H 1887; Duval county, C 3839; Eustis, N 1033, H 1885; Tavares, R 207; Jupiter, C 5538; New River, H 1886.

1258. **Lophiola aurea,** Ker. De Funiak, C 5909.

1259. **Aletris aurea,** Walt. Madison county, H 1884; Lake City, R. 244, 595, 1247, 1329, H 1878, 1881; Duval county, C 2841, 6412 (*A. farinosa*); E. Fla., H 1880; Eustis, N 540, H 1879; Hernando county, H 1883; Polk county, R 596, 1416; New River, H 1882. I am unable to separate *A. farinosa*.

DIOSCOREACEAE.

1260. **Dioscorea villosa,** L. Jefferson county, H 1888; Lake City, R 266, 1233, H 1889; Duval county, C.

ROXBURGHIACEAE.

1261. **Croomia pauciflora,** Torr. Chattahoochee, C 2876.

LILIACEAE.

1262. **Smilax tamnoides,** L. Lake City, H 1912; E. Fla., H 1907; Lemon City, H 1910.

1263. **Smilax bona-nox,** L. Tallahassee, N 2405; Jefferson county, H 1905, 1911; Duval county, C 4631; Lake City, R 1347; Levy county, H 1909; Eustis, H 1899; Hernando county, H 1908; Lemon City, H 1903, 1904; Manatee, S 24.

1264. **Smilax pseudo-china,** L. Lake City, 264.

1265. **Smilax glauca,** Walt. Jefferson county, H 1902; Lake City, R 662, H 1901; Duval county, C 4674.

1266. **Smilax pumila,** Walt. Duval county, C 5573; Eustis, N 1627, H 1898.

1267. **Smilax walteri,** Pursh. Lake City, R 267, 373, N 2228; Duval county, C 2863, 6355.
1268. **Smilax laurifolia,** L. Jefferson county, H 1914; Lake City, R 268, 1915; Duval county, C 516, 2872; Eustis, N 1603, H 1916; Palm Beach, H 1913; Pasco county, B 2532.
1269. **Smilax auriculata,** Walt. Lake City, N 2195, R ——; Duval county, C 2864; Eustis, N 569; Polk county, R 1410, 263; Palm Beach, W 432, H 1900, W 260; Miami, P 241, 240; Manatee, S 26, 70.
1270. **Smilax lanceolata,** L. Lake City, N 2194.
1271. **Smilax havanensis,** Jacq. Grassy Key, C 5636; Cocoanutgrove, W 353; Big Pine Key, S 169.
1272. **Allium mutabile,** Michx. Pensacola, R 269; Duval county, C 5670.
1273. **Nothoscordum striatum,** Kunth. River Junction, C 6368.
1274. **Nolina brittoniana,** Nash. Eustis, H 1893; ——, R 1319.
1275. **Nolina georgiana,** Michx. Eau Gallie, C 5702, 2937.
1276. **Lilium catesbaei,** Walt. Baldwin, N 2321; New River, H 1890.
1277. **Yucca aloifolia,** L. Marion county, H 1894; Duval county, C 2952; Eustis, N 936.
1278. **Yucca filamentosa,** L. Jefferson county, H 1897; Madison county, H 1896; Lake City, R 656, 1234, 1895; Eustis, N 1562; Duval county, C 4780.
1279. **Melanthium virginicum,** L. De Funiak, R 181; Lake City, R 1370.
1280. **Zygadenus glaberrimus,** Michx. W. Fla., C 2889; De Funiak, R 1230; Argyle, C.
1281. **Amianthium angustifolium,** Gray. Lake City, R 1330, 1331; ——, R 243, 271; Pasco county, B 2700; St. Augustine, C 6366.
1282. **Amianthium muscaetoxicum,** Gray. Walton county, C 2897; Florala, C 6407.
1283. **Schoenocaulon gracilis,** Gray. Alachua county, H 1891; Eustis, N 2616, 297, H 1892; Mosquito Lagoon, C 2900; Eau Gallie, C; Putnam county, B 2082.
1284. **Chamaelirium luteum,** Gray. Duval county, C 2903; Eustis, N 1379.
1285. **Pleea tenuifolia,** Michx. Walton county, C 2904.
1286. **Tofieldia pubens,** Ait. De Funiak, C 5908; Lake City, R 234.

PONTEDERIACEAE.

1287. **Pontederia cordata,** L. Madison county, H 1921; Lake City, R 519, H 1919; Duval county, C 2988, H 2451; New River, H 1918.
1288. **Pontederia cordata angustifolia,** Torr. Lake City, R 518; Duval county, C 2988*; Eustis, N 450, H 1917, 1920; Polk county, R 520.
1289. **Eichhornia crassipes,** Solms. Marion county, H 1922; Duval county, C 5867, H 2450; Eustis, N 801, H 1923.

XYRIDACEAE.

1290. **Xyris brevifolia,** Michx. Lake City, R 567; Duval county, C 5684; Eustis, N 363; Kissimmee, R 792.
1291. **Xyris flabelliformis,** Chapm. Duval county, C 5666.
1292. **Xyris ambigua,** Beyr. Walton county, C 3002; Apalachicola, C 3002; Jefferson county, H 1924; Duval county, C 5290.
1293. **Xyris elliottii,** Chapm. Levy county, H 1926; Eustis, N 1305, H 1927, 1928; Hernando county, 1925; Hillsboro county, B 2748.
1294. **Xyris communis,** Kunth. Lake City, H 1937; Duval county, C 6021; Citrus county, H 1938; Rockledge, C 5731.

1295. **Xyris elata,** Chapm. Lake City, R 563; Eustis, N 766, H 1936.
1296. **Xyris smalliana,** Nash. Eustis, N 1584, 1585; Tavares, R 560.
1297. **Xyris caroliniana,** Walt. Quincy, N 2563; Lake City, R 566, 1176; Baldwin, R 562; Archer, R 1120.
1298. **Xyris platylepis,** Chapm. Lake City, H 1929, R 1244; Duval county, 5748, C 3011; Baldwin, N 2413; Eustis, N 1378, H 1930.
1299. **Xyris fimbriata,** Ell. Eustis, N 1461; Polk county, R 561, ——, S; Duval county, C 5232.
1300. **Xyris torta,** J. E. Smith. Lake City, R 376, N 2201, H 1933; Falling Creek, R 382; Duval county, C 3013; Eustis, N 954, H 1935; Tavares, R 905; Hernando county, H 1932; Tampa, R 1131; New River, H 1931, 1934.
1301. **Xyris baldwiniana,** R. & S. Walton county, C 3015, 3014; Eustis, N 764; Polk county, R 559, 1374.

COMMELYNACEAE.

1302. **Commelyna nudiflora,** L. River Junction, C 5991; Tallahassee, N 2315; Palm Beach, H 1944, ——, S (1889).
1303. **Commelyna virginica,** L. Eustis, H 1945, N 1157; Hernando county, H 1946; Coon Key, S 241.
1304. **Commelyna angustifolia,** Michx. Alachua county, H 1948; Eustis, N 387, H 1949; Polk county, R 1399, 50; Miami, P 232.
1305. **Commelyna hirtella,** Vahl. Duval county, C 5762; Lower St. John's River, C 2993.
1306. **Commelyna erecta,** L. Duval county, C 5762, H 2452; Tampa, N 2465; Lake City, H 1947.
1307. **Tradescantia floridana,** Wats. Palm Beach, C 5409, W 219; Merritt's I., C 2995*.
1308. **Tradescantia rosea,** Vent. Levy county, H 1939; Duval county, C 2998; Eustis, H 1940; Sanford, R 49, 610; Polk county, R 48, 1401; Putnam county, B 2184.
1309. **Tradescantia reflexa,** Raf. Madison county, H 1941; Lake City, H 1943; Banks of St. John's River, C 2996 in part; Duval county, C.
1310. **Tradescantia longifolia,** Small. Duval county, C 5672; Polk county, R 47.
1311. **Tradescantia foliosa,** Small. Eustis, N 610 ("in part," according to Small), H 1941.

MAYACACEAE.

1312. **Mayaca michauxii,** S. & E. Walton county, C 2999, 5094, Eustis, N 714, H 1950.

JUNCACEAE.

1313. **Juncus effusus,** L. Jefferson county, H 1953; Duval county, H 2455; Lake City, H 1952; Eustis, H 1951, N 452.
1314. **Juncus setaceus,** Rostk. River Junction, C 5897; Lake City, R 870.
1315. **Juncus dichotomus,** Ell. Jefferson county, H 1956; Lake City, H 1955; Duval county, C 5660, 4735; Eustis, N 353, H 1954, 1971; Tampa, R 1117.
1316. **Juncus scirpoides,** Lam. Jefferson county, H 1958, 1967; Madison county, H 1950; Duval county, H 2454; Marion county, H 1962; Lake City, R 914, 915, 907, 888, H 1966; Citrus county, H 1963; Eustis, N 917, 2017, H 1957, 1960; Tavares, R 904, 906; E. Fla., H 1965; Palma Sola Bay, S; New River, H 1964.

1317. **Juncus polycephalus,** Ell. Jefferson county, H 1961.
1318. **Juncus megacephalus,** M. A. Curtis. Tampa, R 1118; Miami, P 258.
1319. **Juncus elliottii,** Chapm. Jefferson county, H 1958; Duval county, C 5417; Eustis, N 338.
1320. **Juncus abortivus,** Chapm. Apalachicola, C 2350*. This is probably not a good species.
1321. **Juncus acuminatus,** Michx. Argyle, C 6405.
1322. **Juncus marginatus,** Rostk. Jefferson county, H 1973; Madison county, H 1972; Lake City, R 910, 892, 875, 871; Eustis, H 1970; Tavares, R 900; Hernando county, H 1974, 1977, 1980.
1323. Var. **aristulatus,** Coville. Eustis, N 784; New River, H 1969.
1324. Var. **pinetorum,** Coville. Lake City, H 1978, 1979; Baldwin, R 903; Duval county, C 2975, H 2453; Eustis, N 2018, H 1976, N 358; Hernando county, H 1975.
1325. Var. **biflorus,** Chapm. Duval county, C 6414.
1326. **Juncus repens,** Michx. Jefferson county, H 1981; Suwanee county, H 1982; Duval county, C 5679; Eustis, N 1244; Eau Gallie, C 2979.

ALISMACEAE.

1327. **Echinodorus parvulus,** Engelm. Tampa, C 2739.
1328. **Sagittaria lancifolia,** L. Madison county, H 1983; Duval county, H 2457; Lake City, R 523; Eustis, H 1985; Tavares, R 521; E. Fla., H 1984; Polk county, R 522, 1411. All except H 1985 belong to variety *falcata.*
1329. **Sagittaria graminea,** Michx. Palm Beach, H 1988.
1330. Var. **cycloptera,** Smith. Jefferson county, H 1987; Duval county, C 2746, 6354; Eustis, N 432, H 1986; Polk county, R 887, 1380; Pasco county, B 2701.
1331. **Sagittaria subulata,** Buch. Duval county, C 5698, H 2456.
1332. Var. **natans,** Smith. Belair, N 2552; Madison county, H 1989, 1991; Marion county, H 1992; Lake City, R 524; Eustis, H 1990; Duval county, C 6536.
1333. **Sagittaria isoetiformis,** Smith. Eustis, N 158, H 1993.
1334. **Sagittaria filiformis,** Smith. Duval county, C 4891.
1335. **Sagittaria latifolia,** Willd. Lake City, H 1994; Lemon City, H 1995.

NAIADACEAE.

1336. **Triglochin triandra,** Michx. Palm Beach, H 1996.
1337. **Naias major,** All. Cape Romano, C 2705.
1338. **Ruppia maritima,** L. Mangrove Key, P 18.
1339. **Potamogeton lucens,** L. Eustis, N 1750.
1340. **Sabal palmetto,** R. & S. Duval county, C 2677; Manatee, S 47.
1341. **Sabal adansonii,** Guerns. Duval county, C 5784, H 1999; Eustis, N 836, H 1997, 1998.
1342. **Thrinax argentea,** Lodd. Big Pine Key, P 87; Saddle Bunch Key, P 23.
1343. **Thrinax garberi,** Chapm. Cocoanutgrove, C 5485, W 281; Lemon City, H 2000, 2001; Biscayne Bay, C 2679*.
1344. **Thrinax parviflora,** Swartz. Raccoon Key, P 101; Bahia Honda Key, C 2679**; No Name Key, C No. H.
1345. **Serenoa serrulata,** Hook. f. Suwanee county, H 2006; Lake City, H 2007; Eustis, N 644, H 2004, 2005; Polk county, R 699; Lemon City, H 2002, 2003; Manatee, S 38.
1346. **Serenoa eatonia,** Swingle. Eustis, N 999.

1347. **Rhapidophyllum hystrix,** Wendl. Eustis, H 2008.
1348. **Pseudophœnix sargentii,** Wendl. Long Key, C 5637.
1349. **Cocos nucifera,** L. Lemon City, H 2009; Sugar Loaf Key, P 50. Naturalized.

TYPHACEAE.

1350. **Typha angustifolia,** L. Marion county, H 2013; Eustis, H 2014; Pelican Key, S 281.
1351. **Sparganium simplex,** Huds. Duval county, C 2703*.

ARACEAE.

1352. **Arisaema triphyllum,** Torr. Lake City, R 516; Duval county, C 2681.
1353. **Arisaema dracontium,** Schott. Columbia county, H 2015; Lake City, R 1084, H 2016.
1354. **Peltandra virginica,** Raf. Eustis, H 2017; New River, H 2018.
1355. **Peltandra alba,** Raf. Lake City, R 517, 926, H 2019; Eustis, H 2020; Crest View, C.
1356. **Pistia spathulata,** Michx. St. John's River and Hillsboro River, C 2687; Istachatta, C 5960; ——, S.
1357. **Orontium aquaticum,** L. Lake City, R 660; Eustis, N 536.
1358. **Colocasia esculenta,** Schott. (?) Escaped, and well established around Lake City; Polk county, R 1350.

LEMNACEAE.

1359. **Spirodela polyrhiza,** Schleid. Columbia county, H 2023; Titusville, N 2282.
1360. **Lemna minor,** L. Marion county, H 2021; Enterprise, C 2695.
1361. **Lemna cyclostasa,** Chev. Lake City, H 2025 in part; Eustis, N 894.
1362. **Lemna perpusilla,** Torr. Columbia county, H 2024; Lake City, H 2025 in part; Eustis, N 1591.
1363. **Wolffiella floridana,** Thompson. Lake City, H 2025 in part; Daytonia, C 2699*; Eustis, N 254.

ERIOCAULONACEAE.

1364. **Eriocaulon decangulare,** L. Duval county, C 3016, R 877; Grand Island, R 233; Lake City, R 893, 1173, H 2031; Eustis, N 847, 1722, H 2039; Tavares, R 1339; Hernando county, H 2033; New River, H 2032.
1365. **Eriocaulon compressum,** Lam. Jefferson county, H 2027; Lake City, R 1235, 1356, in part; Duval county, C 3017; Eustis, N 92, H 2036; Alachua county, H 2028; Kissimmee, R 241.
1366. **Paepalanthus flavidulus,** Kunth. Jefferson county, H 2034; Suwanee county, H 2038; Lake City, R 1383, H 2036; Eustis, N 143, H 2037; Hernando county, H 2035; Kissimmee, R 242.
1367. **Lachnocaulon anceps,** Walt. Lake City, H 2044; Duval county, C 3021; Eustis, N 1942, H 2043; Hernando county, H 2045.
1368. **Lachnocaulon glabrum,** Korn. Eustis, N 1184, 1981; New River, H 2029.
1369. **Lachnocaulon beyrichiana,** Sporl. Walton county, C 3022, 5911; Jefferson county, H 2040; Madison county, H 2041; Eustis, N 1295, 148, 1855, H 2039; Hernando county, H 2042.

CYPERACEAE.

1370. **Cyperus squarrosus,** L. Lake City, N 2243, R 921.
1371. **Cyperus flavescens,** L. Madison county, H 2081; Marion county, H 2082; Duval county, R 878.
1372. **Cyperus leucolepis,** Carey. Eustis, N 1407; Istachatta, C 5969; Tampa, N 2476.

1373. **Cyperus nuttallii,** Torr. Duval county, H 2563; Indian River, C 3050; Eustis, H 2064; Eau Gallie, C 5718; Palm Beach, W 409, H 2062, 2065; New River, H 2063; Tampa, R 1116; ——, S.

1374. **Cyperus microdontus,** Torr. Jefferson county, H 2075, 2099; Suwanee county, H 2074; Columbia county, H 2073; Lake City, H 2079; Madison county, H 2077; Marion county, H 2092; Citrus county, H 2076; Eustis, H 2078, 2080, N 1023, 2494, 482 (which appears to be *C. nuttallii*).

1375. **Cyperus strigosus,** L. Tallahassee, N 2530; Columbia county, H 2084; Lake City, H 2086; Duval county, H 2562; Hernando county, H 2085; ——, C (second distribution).

1376. **Cyperus brunneus,** Swartz. Merritt's Island, C 3025*; Palm Beach, C 5384, H 2067, 2068; Caxambos Island, S 283; Key Largo, P 171; Upper Metacumbe Key, P 135.

1377. **Cyperus tetragonus,** Ell. Duval county, C 3059; Lake City, N 2506; Palm Beach, H 2087.

1378. **Cyperus ligularis,** L. Mosquito Lagoon, C 3046; Palm Beach, C 5394, H 2072; Palmetto, N 2446.

1379. **Cyperus speciosus,** Vahl. Marion county, H 2090; Duval county, C 3048, 5122, H 2561; Eustis, N 737, H 2089; Tavares, R 901; Palm Beach, W 408, H 2088.

1380. **Cyperus esculentus,** L. Archer, R 911; Lake City, H 2095; Duval county, H 2560; Duval county and Indian river, C 3052; Eustis, H 2091, N 1007; Levy county, H 2094; Citrus county, H 2093.

1381. **Cyperus rotundus,** L. Jefferson county, H 2070; Madison county, H 2071; Eustis, H 2069.

1382. **Cyperus articulatus,** L. Eustis, N 1701, H 2057; Duval county, C 5061, H 2565.

1383. **Cyperus haspan,** L. Jefferson county, H 2098; Duval county, H 2559; Lake City, R 912, 913; Eustis, N 1433, 736, H 2097; Citrus county, H 2096.

1384. **Cyperus lecontei,** Torr. Lake City, R 1175; Indian River, C 3045; Eustis, N 1253, H 2061, 2062; Tavares, R 899; Melbourne, C 5714; Palm Beach, W 410.

1385. **Cyperus virens,** Michx. Suwanee county, H 2100; Indian River, C 3062.

1386. **Cyperus calcaratus,** Nees. Suwanee county, H 2103; Madison county, H 2104; Marion county, H 2106; Lake City, H 2101; Palm Beach, H 2102, 2105

1387. **Cyperus surinamensis,** Rottb. Duval county, C 3032; Eustis, H 2107; Tampa, N 2475.

1388. **Cyperus compressus,** L. Madison county, H 2060; Lake City, H 2059; Duval county, C 3026, H 2564; Eustis, N 1020, H 2058.

1389. **Cyperus filiculmis,** Vahl. Madison county, H 2110; Lake City, H 2109; Duval county, C 3036; Eustis, N 907, H 2108.

1390. **Cyperus ovularis,** Torr. Madison county, H 2111; Suwanee county, H 2114; Levy county, H 2112; Citrus county, H 2113.

1391. **Cyperus retrofractus,** Torr. Duval county, C 5755; Lake City, R 909, 918, H 2066; Eustis, N 1741.

1392. **Cyperus baldwinii,** Torr. Madison county, H 2115; Duval county, H 2558; Lake City, H 2116; Tallahassee, N 2410; Eustis, N 619, 1009; Tampa, R 1114; ——, S.

1393. **Cyperus cylindricus,** Britt. Madison county, H 2121; Archer, R 919; Eustis, N 1196, H 2120, 2123; Tavares, R 898; Levy county, H 2122; Palm Beach, H 2117, 2118, 2119, 2124; Miami, P 257.
1394. **Cyperus cylindrostachys,** Boeckl. Eustis, N 1268.
1395. **Kyllingia pumila,** Michx. Alachua county, H 2181; Lake City, R 886, H 2182; Eustis, N 1066, H 2180.
1396. **Kyllingia odorata,** Vahl. Tallahassee, N 2411; Jefferson county, H 2178; Lake City, H 2179.
1397. **Kyllingia brevifolia,** Rottb. Eustis, N 1036; Tampa, C 3065.
1398. **Dulichium spathaceum,** Rich. Eustis, N 1460, H 2130; Lake City, R 960.
1399. **Lipocarpha maculata,** Torr. Jefferson county, H 2185; Madison county, H 2184; Lake City, H 2186; Eustis, N 1162, H 2183; Duval county, C 5285.
1400. **Fuirena scirpoidea,** Vahl. Suwanee county, H 2169; Duval county, C 3067; Eustis, H 2167; Polk county, R 564; New River, H 2168; ——, S.
1401. **Fuirena squarrosa,** Michx. Jefferson county, H 2174, 2177; Lake City, R 916, 885, H 2171, 2172; Duval county, C 3068, 5582; Eustis, N 910, 1038, H 2170; Citrus county, H 2176; Palm Beach, H 2175; Cocoanut-grove, H 2173.
1402. **Eleocharis interstincta,** R. & S. Madison county, H 2131; Eustis, N 1322.
1403. **Eleocharis cellulosa,** Torr. Titusville, N 2302; Duval county, C 6540.
1404. **Eleocharis elongata,** Chapm. Eustis, N 949, H 2132, 2133.
1405. **Eleocharis ochreata,** Nees. Jefferson county, H 2135; Eustis, N 2077, 107, H 2134; Duval county, C 5694, H 2566; Eau Gallie, C 5806.
1406. **Eleocharis ovata,** R. & S. Jefferson county, H 2136.
1407. **Eleocharis chaetaria,** R. & S. Madison county, H 2138; Lake City, H 2139; Eustis, N 996, H 2140.
1408. **Eleocharis nodulosa,** Schultes. Eustis, N 1209.
1409. **Eleocharis vivipara,** Kunth. Madison county, H 2142; Eustis, N 866, H 2141, 2149; Indian River, C 3072; Tampa, C 3088.
1410. **Eleocharis tuberculosa,** R. & S. Duval county, C 3096.
1411. **Eleocharis microcarpa,** Torr. De Funiak, C 5927; Duval county, C 5669.
1412. **Eleocharis melanocarpa,** Torr. Walton county, C 3082; Jefferson county, H 2143, 2145; Madison county, H 2147; Suwanee county, H 2146; Levy county, H 2144; Duval county, C 5609, 5668.
1413. **Eleocharis tricostata,** Torr. Lake City, R 1180; Duval county, C 5667.
1414. **Eleocharis albida,** Torr. Lake City, H 2148; Duval county, C 5675; Titusville, N 2312.
1415. **Eleocharis arenicola,** Torr. Palm Creek, west of Everglades, C 3073.
1416. **Scirpus nanus,** Spreng. Titusville, N 2311.
1417. **Scirpus americanus,** Pers. Eustis, N 434, H 2224; Duval county, H 2569.
1418. **Scirpus robustus,** Pursh. Duval county, C 5680; Hernando county, H 2230; Cape Sable, S 209.
1419. **Scirpus cylindricus,** Britt. Jefferson county, H 2226; Madison county, H 2225; Lake City, H 2227.
1420. **Scirpus lacustris,** L. Eustis, N 1262; H 2229; Palm Beach, H 2228.

1421. **Scirpus cyperinus,** Britt. Jefferson county, H 2231.
1422. **Scirpus hallii,** Gray. Indian River, C 3118*.
1423. **Fimbristylis castanea,** Vahl. Lake City, R 1172, 1224; Duval county, H 2568; Eustis, N 1186, 1323, 1350, H 2150; Levy county, H 2151; Clearwater, R 1181; Tampa, R 1115.
1424. **Fimbristylis spadicea,** Vahl. Duval county, C 3127, 5697; Hernando county, H 2153; Palm Beach, H 2152.
1425. **Fimbristylis puberula,** Vahl. Suwanee county, H 2156; Lake City, R 884; Eustis, N 1214; Levy county, H 2154; Hernando county, H 2156.
1426. **Fimbristylis laxa,** Vahl. Eustis, N 1760.
1427. **Fimbristylis autumnalis,** R & S. Jefferson county, H 2157; Madison county, H 2159; Lake City, H 2160; N. Fla., H (1894); Duval county, C 3130, 5011, H 2567; Eustis, N 1021, 1265, H 2158; Cocoanut-grove, H 2165.
1428. **Stenophyllus capillaris,** Britt. Madison county, H 2163; Lake City, R 879, H 2162; Levy county, H 2166; Eustis, N 1066*a*, H 2161; Cape Canaveral, C 5711; Palm Beach, H 2164.
1429. **Stenophyllus floridanus,** Britt. Lake City, H 2246; Eustis, N 1423, H 2245.
1430. **Stenophyllus stenophyllus,** Britt. Eustis, N 1320; Levy county, H 2249; Hernando county, H 2247; Palmetto, N 2454.
1431. **Stenophyllus warei,** Britt. Suwanee county, H 2252; Levy county, H 2251; Eustis, N 1165, 1685, H 2250; Hernando county, H 2253; Indian River, C 3135; Palm Beach, C 5526.
1432. **Abildgaardia monostachya,** Vahl. Hernando county, H 2046; No Name Key, C 3136, 5513; Big Pine Key, S 197.
1433. **Rhynchospora cyperoides,** Mart. Lake City, R 880; Biscayne Bay, C 5495.
1434. **Rhynchospora corniculata,** Gray. Lake City, R 1171; Duval county, H 2568.
1435. **Rhynchospora patula,** Gray. Eustis, N 1075, 1384, 1488; Eau Gallie, C 3147.
1436. **Rhynchospora pusilla,** Chapm. Duval county, C 3170; Eustis, N 1975.
1437. **Rhynchospora divergens,** Chapm. Indian River, C 3150*.
1438. **Rhynchospora oligantha,** Gray. Duval county, C 5687.
1439. **Rhynchospora plumosa,** Ell. Argyle, C 6488.
1440. **Rhynchospora intermedia,** Britt. Eustis, N 2020, H 2189; Eau Gallie, C 5703; Mosquito Inlet, C 3173*; ——, S.
1441. **Rhynchospora glomerata,** Vahl. De Funiak, C 5926; Jefferson county, H 2196; Suwanee county, H 2195; Lake City, H 2197; Duval county, C 5739.
1442. **Rhynchospora axillaris,** Britt. Jefferson county, H 2190; Levy county, H 2191; Lake City, H 2193; Baldwin, R 884; Eustis, N 845, H 2192; Hernando county, H 2194.
1443. **Rhynchospora fusca,** R. & S. Milton, C 5929.
1444. **Rhynchospora filifolia,** Gray. Eustis, H 2206; Hernando county, H 2207.
1445. **Rhynchospora distans,** Vahl. Madison county, H 2200; Levy county, H 2201; Lake City, H 2199; Eustis, N 662, 802, 642, H 2202.
1446. **Rhynchospora fascicularis,** Vahl. Eustis, N 641, H 2198.
1447. **Rhynchospora gracilenta,** Gray. Eustis, N 1321; Duval county, C 5072.

1448. **Rhynchospora leptorhyncha,** Wright. Duval county, C 4874.
1449. **Rhynchospora ciliata,** Vahl. Lake City, H 2208; Duval county, C 5416, 4873; Eustis, N 534.
1450. **Rhynchospora grayi,** Kunth. Lake City, H 2205; Eustis, N 406, H 2203; Hernando county, H 2204.
1451. **Rhynchospora dodecandra,** Baldw. Madison county, H 2209; Eustis, N 462, H 2210; Hernando county, H 2212; Palm Beach, C 5389, H 2211.
1452. **Rhynchospora cymosa,** Nutt. River Junction, C.
1453. **Rhynchospora rariflora,** Ell. Eustis, N 2062, 438.
1454. **Rhynchospora microcarpa,** Baldw. Ponce de Leon, C 6482; Indian River, Washington county (A), Jackson county (B), Sumter county (C), C 3149; Suwanee county, H 2215; Lake City, R 908; Eustis N 347, H 2214; Merritt's Island, C 3162; New River, H 2213; Hernando county, H 2216.
1455. **Rhynchospora caduca,** Ell. Madison county, H 2219; Lake City, 2872, H 2220; Duval county, C 5415; Eustis, N 839; Hernando county, H 2217, 2218.
1456. **Rhynchospora milacea,** Gray. Eustis, N 1845, H 2221; ——, S.
1457. **Rhynchospora stenophylla,** Chapm. Walton county, C 3174, 5945.
1458. **Rhynchospora marisculus,** Nees. Eau Gallie, C 5719; Hernando county, H 2223; Mosquito Inlet, C 3174*; Palm Beach, H 2222.
1459. **Chaetospora nigricans,** Kunth. Palm Beach, H 2053.
1460. **Psilocarya nitens,** Ward. Duval county, C 5761; Eustis, N 1294; Citrus county, H 2187; Manatee, S.
1461. **Dichromena leucocephala,** Michx. Columbia county, H 2129; Lake City, R 876, 883, 917; Eustis, N 1045, H 2126; Marion county, B 2021; Citrus county, H 2128; Tampa, R 923; Palm Beach, H 2125, 2127.
1462. **Dichromena latifolia,** Baldw. Lake City, R 890, 894; Duval county, C 3138, N 2595, R 882; Polk county, R 881.
1463. **Cladium effusum,** Torr. Milton, R 666; Marion county, H 2054; Eustis, N 1046, H 2055, 2056; Big Pine Key, S 247.
1464. **Scleria triglomerata,** Michx. Columbia county, H 2234, Lake City, R 1193 in part, H 2735; Duval county, C 3179; Eustis, N 316, H 2232; Hernando county, H 2233; Pasco county, B 2681.
1465. **Scleria oligantha,** Ell. Jefferson county, H 2237; Duval county, C 5665.
1466. **Scleria laxa,** Torr. Duval county, C 3182, 5757; Eustis, N 1339, H 2244.
1467. **Scleria ciliata,** Michx. Duval county, C 3183.
1468. **Scleria elliottii,** Chapm. Duval county, C 3184, 5674; Eustis, N 373.
1469. **Scleria pauciflora,** Muhl. Jefferson county, H 2241; Suwanee county, H 2240; Madison county, H 2239; Marion county, H 2243; Lake City, H 2242; Eustis, N 508, 630, 1040, H 2238; Melbourne, C 5716; Duval county, C 4793; Pasco county, B 2688.
1470. **Scleria baldwinii,** Torr. Duval county, C 3186.
1471. **Scleria gracilis,** Ell. Duval county, C 3187; Hernando county, H 2236.
1472. **Scleria filiformis,** Swartz. Biscayne Bay, C 3188, 5497.
1473. **Scleria verticillata,** Muhl. River Junction, N 2575.
1474. **Scleria hirtella,** Swartz. Duval county, C 3190; Eustis, N 1917.
1475. **Carex stipata,** Muhl. Lake City, R 1174.
1476. **Carex albolutescens,** Schwein. Jefferson county, H 2052; Duval county, C 3193; Eustis, N 1037, H 2051; Tampa, R 1113; Pasco county, B 2694.

1477. **Carex polytrichoides,** Muhl. Duval county, C 3300.
1478. **Carex oxylepis,** T. & H. Chattahoochee, C 3290.
1479. **Carex ptychocarpa,** Steud. Aspalaga, C 3306.
1480. **Carex dasycarpa,** Muhl. Aspalaga and Mosquito Inlet, C 3226; Pasco county, B 2667.
1481. **Carex styloflexa,** Buckl. River Junction, C 6402.
1482. **Carex laxiculmis floridana,** Bailey. River Junction, C 6393.
1483. **Carex verrucosa,** Muhl. Madison county, H 2049; Lake City, N 2222, H 2050; Falling Creek, R 902.
1484. **Carex chapmani,** Sartw. De Funiak Springs, C 6385.
1485. **Carex amphibola,** Steud. River Junction, C 6401; Duval county, C 6356.
1486. **Carex comosa,** Boott. Citrus county, H 2047.
1487. **Carex tentaculata,** Muhl. Lake City, H 2048.
1488. **Carex elliottii,** Schw. & Torr. Walton county, C 3234; Lake City, R 874; Eustis, N 499; De Funiak Springs, C 6380.
1489. **Carex louisianica,** Bailey. Duval county, C 5664; Pasco county, B 2695.

GRAMINEAE.

1490. **Reimaria oligostachya,** Munro. Duval county, C 3596*a*, H 2579.
1491. **Paspalum platycaulon,** Poir. Jefferson county, H 2462, 2463; Suwanee county, H 2460, 2518; Lake City, R 981, H 2461, 2464; Duval county, H 2577; Eustis, N 1219; Myers, R 601.
1492. **Paspalum paspaloides,** Scribn. River Junction, N 2372; Lake City, R 990; Hernando county, H 2465; Duval county, C 3565; Crystal Lake, C 3565*; Eustis, N 509, H 2466.
1493. **Paspalum distichum,** L. Jefferson county, H 2469; Madison county, H 2467; Duval county, C 5741; Eustis, N 1205, 1035, H 2468; Indian River, C 3567* in part; Key West, C 3567; ——, S.
1494. **Paspalum vaginatum,** Swartz. Indian River, C 3567* in part.
1495. **Paspalum ciliatifolium,** Michx. Tallahassee, R 833; Lake City, R 1007, H 2470, 2474, 2475; Duval county, C 6017, 6018; E. Fla., H 2471, 2477; Alachua county, H 2472; Levy county, H 2478, 2480; Eustis, H 2473, 2476; Palm Beach, H 2479.
1496. **Paspalum setaceum,** Michx. Jefferson county, H 2483; Suwanee county, H 2484; Lake City, R 846, 849, H 2485; Duval county, C 3576, 5092, H 2576; Eustis, N 946, H 2481, 2482.
1497. **Paspalum longipedunculatum,** Le Conte. Suwanee county, H 2488; Madison county, H 2487; Levy county, H 2491; Lake City, R 800, 831, 983, 1182, H 2486; E. Fla., H 2490; Eustis, N 629, 600, 1417, H 2493, 2489; New River, H 2492.
1498. **Paspalum racemulosum,** Nutt. Duval county, C 5080.
1499. **Paspalum purpurascens,** Ell. Tallahassee, N 2346; Jefferson county, H 2495; Levy county, H 2494; Lake City, R 819; Duval county, C 5745.
1500. **Paspalum plicatum,** Michx. Pensacola, C 5923; Suwanee county, H 2496, 2506; Madison county, H 2497, 2499; Levy county, H 2501; Lake City, R 811, 767, 1195, 1442; Eustis, N 216, 680; New River, H 2498; ——, R 1044.
1501. **Paspalum cæspitosum,** Flugge. Palm Beach, H 2503; Cocoanut-grove, H 2502; Palmetto, N 2414; No Name Key, C 5440; Sugar Loaf Key, P 74.
1502. **Paspalum simpsoni,** Nash. No Name Key, P 124.

1503. **Paspalum praecox,** Walt. Lake City, H 2504; Duval county, C 3569, 5580; Eustis, N 2047; Hernando county, H 2505.
1504. **Paspalum laeve,** Michx. Tallahassee, N 2344; Chattahoochee, C 5937?; Jefferson county, H 2506; Lake City, R 766, 1184; Duval county, H 2578; Eustis, N 507, 1027, 1340, H 2507.
1505. **Paspalum curtissianum,** Steud. Eau Gallie, C 5728.
1506. **Paspalum difforme,** Le Conte. Duval county, C 5517.
1507. **Paspalum paludosum,** Vasey. Duval county, 5760.
1508. **Paspalum floridanum,** Michx. Lake City, R 820; Duval county, C 5750; Levy county, H 2508.
1509. **Paspalum dilatatum,** Poir. Titusville, N 2298.
1510. **Paspalum giganteum,** Baldw. Duval county, C 3571*; Eustis, N 1754.
1511. **Paspalum fluitans,** Kunth. Eustis, N 1699; Upper St. John's River, C 3563; Istachatta, C 5970.
1512. **Paspalum membranaceum,** Walt. Duval county, C 5081.
1513. **Eriochloa mollis,** Kunth. Suwanee county, H 2331; Eustis, N 2050; Jupiter Inlet, C 5556.
1514. **Eriochloa longifolia,** Vasey. Cape Romano, S 202; Cape Sable, S 165.
1515. **Oplismenus setarius,** R. & S. Tallahassee, N 2524; Jupiter, C 5553; Palm Beach, H 2337; ——, S; Duval county, C 5301.
1516. **Anthænantia villosa,** Benth. Levy county, H 2270; Duval county, C 3596.
1517. **Anthænantia rufa,** Schultes. Duval county, C 3603, N 2594.
1518. **Amphicarpum purshii,** Kunth. Eustis, N 1650.
1519. **Amphicarpum floridanum,** Chapm. Eustis, N 1416, 1182, H 2255.
1520. **Panicum simpsoni,** Beal. St. Augustine, C 6122.
1521. **Panicum sanguinale,** L. Jefferson county, H 2511, 2513; Suwanee county, H 2512; Levy county, H 2510; Lake City, H 2509; E. Fla., H 2515; Eustis, N 2105, H 2514, 2516.
1522. **Panicum filiforme,** L. Alachua county, H 2526; Lake City, R 768; Duval county, C 3590, 6053; Eustis, N 1019, H 2527; Miami, P 214.
1523. **Panicum glabrum,** Gaud. Hernando county, H 2517.
1524. **Panicum setigerum,** Roth. Duval county, H 2575; Eustis, N 996; Palm Beach, H 2518, 2519, 2520, 2521; Lemon City, H 2522; Key Largo, P 205.
1525. **Panicum serotinum,** Trin. Jefferson county, H 2524; Lake City, N 1264, H 2525; Duval county, C 3604*a*, H 2574; ——, R 1046.
1526. **Panicum chapmanii,** Vasey. Key Largo, C 5457; Cape Sable, S 157; Little Pine Key, C 3607.
1527. **Panicum curtisii,** Chapm. Madison county, H 2529; Citrus county, H 2530; Lake City, R 859, H 2528; Duval county, C 3585; Eustis, N 745, H 2531.
1528. **Panicum paspaloides,** Pers. Lake City, R 1194; Eustis, N 746; Manatee, S.
1529. **Panicum fuscum,** Swartz. Caxambos Key, S 275; Sand Key, C 3606**.
1530. **Panicum fasciculatum,** Swartz. Sanibel I., S 292; Cape Canaveral, C 3589; Key West, C 5431.
1531. **Panicum leucophaeum,** HBK. Eustis, N 1728; Cape Canaveral, C 3597*; Hypoluxo I., C 5393; Key Largo, P 174.
1532. **Panicum verrucosum,** Muhl. Duval county, C 5807; Lake City, R 762, 848; Eustis, N 780, H 2532.

1533. **Panicum proliferum,** Lam. Palm Beach, C 5386.
1534. **Panicum hians,** Ell. Jefferson county, H 2551; Suwanee county, H 2552; Jupiter, C 5534; Pease Creek, C 3594; Eustis, N 213.
1535. **Panicum agrostoides,** Spreng. Duval county, C 5576; Palm Beach, H 2557.
1536. **Panicum anceps,** Michx. Tallahassee, N 2529; Columbia county, H 2558; Duval county, C 3579, C 5747; Eustis, H 2559; New River, H 2560.
1537. **Panicum pseudanceps,** Nash. ——.
1538. **Panicum stenodes,** Griseb. Duval county, N 2249, C 3579; Citrus county, H 2538; Hernando county, H 2537; New River, H 2539, 2540, 2541.
1539. **Panicum gymnocarpum,** Ell. Chattahoochee, C 5936.
1540. **Panicum virgatum,** L. Eustis, N 1761; Levy county, H 2544, 2545; Hernando county, H 2542, 2543; Big Pine Key, S 335; Lake City, R 1197.
1541. **Panicum amarum,** Ell. Indian River, C 3578; Palm Beach, C 5527, H 2554, 2556.
1542. **Panicum jumentorum,** Pers. Lake City, R 844; Eustis, N 1730, H 2553; Cape Canaveral, C 3597**.
1543. **Panicum autumnale,** Bosc. Eustis, N 40, H 2546.
1544. **Panicum porterianum,** Nash. Tallahassee, N 2329; Jefferson county, H 2576, 2577; Lake City, R 817.
1545. **Panicum commutatum,** Schultes. Madison county, H 2582; Lake City, R 839, 823, 826, 842, H 2581; Eustis, N 240, 1119, H 2578; Palm Beach, H 2583.
1546. **Panicum equilaterale,** Scribn. Eustis, N 1120.
1547. **Panicum webberianum,** Nash. Jefferson county, H 2602; Eustis, N 781, 376, H 2603, 2607; Palm Beach, H 2606; New River, H 2604, 2605.
1548. **Panicum erectifolium,** Nash. Jefferson county, H 2598; E. Fla., H 2599; Hernando county, H 2597; Mosquito Inlet, C 3599.
1549. **Panicum malacon,** Nash. Columbia county, H 2566; Lake City, R 841, 1004, 1030, 1034, 1055; Eustis, N 628, H 2563, 2564; Levy county, H 2565; Duval county, C 5864; Miami, P 223.
1550. **Panicum ciliiferum,** Nash. Madison county, H 2567; Columbia county, H 2568; Lake City, R 784, 790, 805, 830, 861, 863, 930, 1006, 1012, 1017, 1016, 1058, 1035, 1033, 1037, 1039, 1354, 1447, 1449; Hammock Ridge, R 1054; Marion county, H 2570; Alachua county, H 2569; Duval county, C 5866; Eustis, N 96, 1518.
1551. **Panicum angustifolium,** Ell. Series A (N 301). Lake City, R 802, 838, 840; Eustis, N 301, 466; Santa Rosa county, C 3583*; Sumter county, C 3600 A.

    Series B (N 1226). Jefferson county, H 2589, 2594; Madison county, H 2593; Lake City, H 2596; Suwanee county, H 2591; Citrus county, H 2590; Eustis, N 1226, H 2588; Hernando county, H 2592, 2595.
1552. **Panicum ensifolium,** Baldw. Lake City, R 795; Eustis, N 424.
1553. **Panicum ciliatum,** Ell. Eustis, N 807.
1554. **Panicum dichotomum,** L. Eustis, N 337.
1555. **Panicum baldwinii,** Nutt. Duval county, C 5588; Melbourne, C 5804; Eustis, N 335.
1556. **Panicum neuranthum,** Griseb. Duval county, Calkins, H 2573; Eustis, N 1243.

1557. **Panicum albo-marginatum,** Nash. Eustis, N 925.

1558. **Panicum leucothrix,** Nash. De Funiak, C 5912; Jefferson county, H 2574; Suwanee county, H 2573; Lake City, R 1005, 1013, 1014, 1060, H 2572; Duval county, Calkins; Eustis, N 467, 334, 1338, 2075, H 2601; Hernando county, H 2575; Kissimmee, R 791; New River, H 2600.

1559. **Panicum barbulatum,** Michx. Tallahassee, N 2522; Jefferson county, H 2583; Duval county, H 2571; Lake City, R 980.

1560. **Panicum laxiflorum,** Lam. Lake City, N 2156, R 827, 822, H 2584, 2585; Eustis, N 239, H 2586; Jupiter, C 5537; Hernando county, H 2587.

1561. **Panicum shagnicolum,** Nash. Lake City, N 2500, R 761; Argyle, C 6403.

1562. **Panicum divaricatum,** L. Indian River, C 3588; Palm Beach, C 5530, H 2547; Miami, R 935; Key Largo, P 157.

1563. **Panicum crus-galli,** L. Lake City, R 804, 1031, 1036; Duval county, H 2572; Palm Beach, H 2561, 2562; ——, S 43.

1564. **Panicum hispidum,** Forst. Lake City, H 2550; Marion, H 2548; Citrus county, H 2549.

1565. **Panicum colonum,** L. Chattahoochee, C 5999; Tallahassee, N 2337; Key West, Calkins.

1566. **Panicum gibbum,** Ell. Madison county, H 2533; Lake City, R 1028; Eustis, N 1024, H 2534; Palm Beach, H 2535, 2536.

1567. **Panicum sp.** (Nash 375). Lake City, R 809, 803, 929, 1015. 1020, 1042, 1059, 1038, 1193; Eustis, N 375.

1568. **Setaria imberbis.** Jefferson county, H 2344, 2350; Duval county, H 2580; Alachua county, R 824, H 2347; Eustis, H 2345; Levy county, H 2346; Lake City, R 862, H 2348; Hernando county, H 2349.

1569. **Setaria italica,** Kunth. Merritt's Island, C 3618.

1570. **Setaria corrugata parviflora.** Lake City, R 760, 829; Eustis, N 1382.

1571. **Setaria flava,** Kunth. Duval county, C 5411; Eustis, N 566.

1572. **Setaria corrugata,** Schultes. Lake City, R 845; Duval county, C 3616; Levy county, H 2356; Eustis, N 640, H 2352; Palm Beach, H 2351; Miami, P 253.

1573. **Setaria macrosperma,** (Scrib. & Merr.) Lake City, R 772; Howe's Key, S 263; Key Largo, C 5502.

1574. **Setaria magna,** Griseb. Eustis, N 1279; Palm Beach, C 5410.

1575. **Cenchrus echinatus,** L. Madison county, H 2281; Lake City, R 853, 1011, 1196, H 2278; E. Fla., H 2280; Archer, R 816; Duval county, C 3619; Eustis, H 2279; Upper Metacumbe Key, P 145; ——, S (1889).

1576. **Cenchrus tribuloides,** L. Lake City, R 852, 1010; Oxford, R 759; Eustis, N 364, H 2282, 2285; Duval county, C 3620, 6020; E. Fla., H 2286; Palm Beach, H 2283, 2284, 2287; Elliott's Key, P 213; Key Largo, P 167.

1577. **Cenchrus gracillimus,** Nash. Suwanee county, H 2290; Lake City, H 2291; Eustis, H 2288, 2289.

1578. **Cenchrus incertus,** Curtiss. River Junction, N 2580; Duval county, C 6019.

1579. **Cenchrus myosuroides,** HBK. Caxambos Island, S; Indian Key, C 5643.

1580. **Stenotaphrum americanum,** Schrank. Lake City, H 2377; Duval county, C 3621; Jupiter Inlet, C 5547; Leesburg, R 801.

1581. **Leersia monandra,** Swartz. Key Largo, C 3359; Losman's Key, S 202.
1582. **Leersia hexandra,** Swartz. Duval county, C 3363; Eustis, N 800, H 2336.
1583. **Hydrochloa carolinensis,** Beauv. Lloyd, N 2512; Duval county, C 5742; Eustis, H 2334.
1584. **Zizania aquatica,** L. Marion county, H 2391.
1585. **Rottboellia rugosa,** Nutt. Duval county, C 3622; Hernando county, H 2341; Palm Beach, H 2342.
1586. **Rottboellia rugosa chapmanii,** Hack. Eustis, N 1074, H 2343.
1587. **Rottboellia cylindrica,** Chapm. Suwanee county, H 2340.
1588. **Tripsacum dactyloides,** L. Eustis, N 374; Lake City, R 806, N 2207; Hernando county, H 2384; Miami, P 272.
1589. **Elionurus tripsacoides,** HBK. Sanford, N 2271; Caloosa River, C 3630; New River, H 2315; Cocoanutgrove, C 5472.
1590. **Andropogon tener,** Kunth. Lake City, R 986; River Junction, N 2576; McClenny, C 5978.
1591. **Andropogon semiberbis,** Kunth. Eau Gallie, C 3633; Cocoanutgrove, H 2256; Cutler, C 5473.
1592. **Andropogon elliottii,** Chapm. Duval county, C 3636, 6016, 6076; Eustis, N 1597.
1593. **Andropogon gracilis,** Spreng. Miami, C 5408.
1594. **Andropogon argyraeus,** Schultes. Madison county, H 2258; Lake City, R 866, H 2259; Duval county, C 3637, 5799; Eustis, N 489, H 2257.
1595. **Andropogon longiberbis,** Hack. Lake City, R 770, 896; Eustis, N 645, 1194; Palm Beach, H 2264; New River, H 2260, 2261, 2262, 2263.
1596. **Andropogon virginicus,** L. Suwanee county, H 2266; Duval county, C 3636, 5571, 6054, 6055, 6075; Archer, R 815; Eustis, H 2265.
1597. **Andropogon brachystachyus,** Chapm. Eustis, N 1193, H 2267.
1598. **Andropogon floridanus,** Scribn. Eustis, N 1572, H 2268.
1599. **Andropogon flexilis,** Bosc. Palmetto, N 2443.
1600. **Andropogon macrourus,** Michx. Duval county, C 3639, 6077, 6078, 6079; Palm Beach, H 2269.
1601. **Heteropogon acuminatus,** Trin. Lake City, R 771, 796, 832; Duval county, C 3641, 5583; New River, H 2378. Lower and less robust; leaves conspicuously ciliate for half the distance; no pits along the midrib of sheath.
1602. **Imperata braziliensis,** Trin. Hernando county, H 2335; Key West, C 3626*; ——, S. Curtiss specimen seems to be different.
1603. **Erianthus alopecuroides,** Ell. Duval county, C 3627.
1604. **Sorghum halapense,** Pers. Jefferson county, H 2357; Lake City, R 810, 1009, 1043; Merritt's Island, C 5724; Eustis, N 1435, H 2356; No Name Key, P 120 (*drummondii*).
1605. **Sorghum secundum,** Chapm. Duval county, C 3644; New River, H 2358; Tampa, R 1125.
1606. **Phalaris intermedia,** Bosc. Lake City, R 778.
1607. **Sporobolus domingensis,** Kunth. Hernando county, H 2365; Boca Chica Key, C 3382*; Long Key, C 5444; Sugar Loaf Key, P 30.
1608. **Sporobolus junceus,** Kunth. Jefferson county, H 2372; Madison county, H 2371; Alachua county, H 2369; Citrus county, H 2370; Lake City, R 828, 799, 1019, 1032, 1040; Duval county, C 3377, 5659; Eustis, N 144, H 2368; Hernando county, H 2367.
1609. **Sporobolus curtissii,** Small. Lake City, R 786, 1050, R 1179, N 2213, H 2373; Duval county, C 3379*.

1610. **Sporobolus indicus,** Brown. Lake City, R 1021, 1190, 1191, 1186, 1189, H 2376; Archer, R 825; E. Fla., H 2375; Duval county, C 3383, H 2582; Eustis, N 1006; Palm Beach, H 2374.

1611. **Sporobolus virginicus,** Kunth. Hernando county, H 2306; Tampa, N 2467; Jupiter Inlet, C 5554; Cape Florida, C 5478; Anna Maria Key.

1612. **Sporobolus asper,** Kunth. Duval county, C 5794.

1613. **Agrostis scabra,** Willd. Tallahassee, C 3386; Eustis, N 370.

1614. **Agrostis alba,** L. De Funiak, R 922; Alachua county, H 2254.

1615. **Calamagrostis curtissii,** Vasey. Merritt's I., C 3412, 5729.

1616. **Stipa avenaceoides,** Nash. Eau Gallie, C 5834; Eustis, N 2051.

1617. **Aristida patula,** Chapm. Indian river, C 3431*; Titusville, N 2295; Jupiter, C 5535; Hernando county, H 2272.

1618. **Aristida simplicifolia,** Chapm. Walton county, C 3424*.

1619. **Aristida purpurascens,** Poir. Tampa, N 2424.

1620. **Aristida palustris,** Vasey. Lake City, R 679, 788, 1052, 1446; Tampa, N 2419.

1621. **Aristida virgata,** Trin. Duval county, C 5801, 5183.

1622. **Aristida stricta,** Michx. Madison county, H 2275; Lake City, H 2276; Duval county, C 3426; Eustis, N 1620, 1736, H 2276; Palm Beach, H 2273.

1623. **Aristida spiciformis,** Ell. Lake City, R 868; Duval county, C 3427; Tampa, N 2418.

1624. **Aristida sp.** Lake City, R 985, H 2271; Eustis, N 1682, 1642.

1625. **Muhlenbergia capillaris,** Kunth. Lake City, R 785, 865, 1049, 1445; Duval county, C 3401.

1626. **Muhlenbergia trichopodes,** Chapm. Duval county, C 3402, 5785, N 2323.

1627. **Phleum pratense,** L. Alachua county, H 2338; New River, H 2625, escaped.

1628. **Danthonia sericea,** Nutt. Chattahoochee, C 5876.

1629. **Spartina juncea,** Willd. Eustis, H 2359, 2360; Hernando county, H 2362; Duval county, H 2581; Palmetto, N 2439; Palm Beach, H 2361; ——, Buckley.

1630. **Spartina junciformis,** Engelm. & Gray. Hernando county, H 2363; Key West, S.

1631. **Spartina polystachya,** Willd. Duval county, C 5518.

1632. **Spartina stricta,** Roth. Duval county, C 5577; E. Fla., H 2364; Palmetto, N 2437.

1633. **Gymnopogon racemosus,** Beauv. Duval county, C 3441; New River, H 2333.

1634. **Chloris petraea,** Swartz. Suwanee county, H 2295; Levy county, H 2294; Eustis, N 217; E. Fla., H 2292; Hernando county, H 2293; Elliott's Key, P 213*a*.

1635. **Chloris glauca,** Vasey. Duval county, C 3444; Eustis, H 2139; Sanford, R 843; Hernando county, H 2296; Palm Beach, H 2297, 2298.

1636. **Chloris neglecta,** Nash. Duval county, C 3445; Alachua county, H 2300; Eustis, N 2149, 2299; Sugar Loaf Key, P 69.

1637. **Chloris floridana,** Vasey. Lake City, N 2198, H 2301; Duval county, C 6429.

1638. **Chloris polydactyla,** Swartz. Key Largo, P 152.

1639. **Cynodon dactylon,** Pers. Suwanee county, H 2303; Lake City, R 774; H 2305; Duval county, C 5691, 5776; Indian River, C 3446; E. Fla., H 2606; Eustis, H 2307; Palm Beach, H 2304.

1640. Var. **maritimus,** Nees. Indian River, C 3446 in part; Eau Gallie, C 5712; Pine Island, S 304.
1641. **Ctenium americanum,** Spreng. De Funiak, R 182; Jefferson county, H 2302; Lake City, R 1192; Duval county, C 3437; Eustis, N 2056.
1642. **Ctenium chapadensis,** Trin. Lake City, N 2212.
1643. **Eleusine ægyptiaca,** Pers. Lake City, R 773, 797, 857, 979, 1231; Duval county, C 3447; Eustis, N 1047.
1644. **Eleusine indica,** Gaertn. Jefferson county, H 2313; Lake City, R 854, 1023, 1024, 1183, H 2314; E. Fla., H 2312; Eustis, H 2310; Palm Beach, H 2311.
1645. **Leptochloa mucronata,** Kunth. Chattahoochee, C 5998.
1646. **Monanthochloe littoralis,** Engelm. Boca Chica Key, C 3646, 5433; Key West, C 5618.
1647. **Diplachne fascicularis,** Gray. Titusville, N 2306; Hernando county, H 2308.
1648. **Triodia cuprea,** Jacq. Tallahassee, N 2406; Ormond, C 5564; New River, H 2379; Duval county, C 5562*a*.
1649. **Triodia ambigua,** Vasey. Duval county, C (1875).
1650. **Triplasis intermedia,** Nash. Suwanee county, H 2383; Tampa, N 2426.
1651. **Triplasis americana,** Beauv. Lake City, R 765; Duval county, C 5570; Eustis, H 2382.
1652. **Triplasis purpurea,** Hack. Madison county, H 2381; Alachua county, H 2380; Duval county, C 3456, 5795.
1653. **Festuca sciuris,** Nutt. Madison county, H 2332; Lake City, R 1002, 1003, 1056, 1057, 1448, 869, 793.
1654. **Eatonia obtusata,** Gray. Lake City, R 837.
1655. **Eatonia pennsylvanica,** Gray. Lake City, R 782.
1656. **Eatonia filiformis,** Vasey. Eustis, N 97.
1657. **Poa chapmanii,** Scribn. Lake City, R 777.
1658. **Poa pratensis,** L. Lake City, R 783.
1659. **Eragrostis brownei,** Nees. De Funiak, C 5925; Jefferson county, H 2318; Lake City, R 855, 1185, 1187, H 2316; Baker county, C 3492*; Eustis, N 1611, H 2317; Istachatta, C 5073.
1660. **Eragrostis conferta,** Trin. Apalachicola River, C 3497.
1661. **Eragrostis ciliaris,** Link. Suwanee county, H 2320; Chattahoochee, C 5895; Eustis, N 1327, H 2321; Pease Creek, C 3493; Palm Beach, H 2319; Upper Metacumbe Key, P 146.
1662. **Eragrostis plumosa,** Link. Marion county, H 2322; Lake City, R 856, 1188, N 2157.
1663. **Eragrostis pilosa,** Beauv. Jefferson county, H 2323; Lake City, N 2199; Melbourne, C 5585.
1664. **Eragrostis purshii,** Schrad. Milton, C 5930; Jefferson county, H 2324; Madison county, H 2326; Alachua county, H 2325.
1665. **Eragrostis lugens,** Nees. Tampa, C 3494*.
1666. **Eragrostis elliottii,** Wats. Alachua county, H 2327; Lake City, R 1051; Duval county, C 3500, 5567.
1667. **Eragrostis pectinacea,** Gray. E. Fla., H 2328; Duval county, C 5792.
1668. **Eragrostis hirsuta,** Nash. Tallahassee, N 2521; Duval county, C 5572.
1669. **Eragrostis campestris,** Trin. Lake City, R 787; Duval county, C 5569; Eustis, N 1656.
1670. **Eragrostis refracta,** Scribn. Suwanee county, H 2330; Citrus county, H 2329; Lake City, R 897.

1671. **Uniola latifolia,** Michx. Chattahoochee, C 5938.
1672. **Uniola paniculata,** L. Duval county, 3518; Palm Beach, C 5401, H 2385; Lemon City, H 2386; Key West, Blodgett.
1673. **Uniola gracilis,** Michx. Jefferson county, H 2389; Lake City, R 789; 798, 812, 1027, 1029, 1053, 1047, 1444, H 2390; Eustis, N 1542, H 2388.
1674. **Uniola longifolia,** Scribn. Tallahassee, N 2407; Ormond, C 5563, Eustis, N 1498; Citrus county, H 2387.
1675. **Uniola nitida,** Baldw. Lake City, R 813, 1026; Duval county, C 3521, R 1045, 1443.
1676. **Phragmites communis,** Trin. Palm Beach, H 2339.
1677. **Distichlis maritima,** Raf. Duval county, C 3476, 5187; Hernando county, H 2309.
1678. **Lolium perenne,** L. Lake City, 1048, 1199, 784, 850, probably escaped.
1679. **Hordeum pratense,** Huds. Lake City, R 781.
1680. **Elymus virginicus,** L. Duval county, C 5586.
1681. **Arundinaria macrosperma,** Michx.
1682. **Arundinaria tecta,** Muhl. Tallahassee, N 2528; Jefferson county, H 2623.

CONIFERAE.

1683. **Pinus clausa,** Vasey. Apalachicola, C 2655*; Tallahassee, R 478; Eustis, N 2111, R 479; Jupiter Inlet, C 5558; Jensen, R 947.
1684. **Pinus glabra,** Walt. Chattahoochee, C 2656; Lake City, R 705, H 2459.
1685. **Pinus echinatus,** Mill. Chattahoochee, C 2658; Lake City, N 2238; Hernando county, H 2449; Palm Beach, H 2450.
1686. **Pinus rigida,** Mill. Jefferson county, H 2451.
1687. **Pinus serotina,** Michx. Eustis, N 1397, H 2454, 2456.
1688. **Pinus taeda,** L. Jefferson county, H 2452; Lake City, R 665, 931, N 2235, H 2453, 2457, 2458.
1689. **Pinus heterophylla,** Sudw. Lake City, R 705; Duval county, C 2651*a*; E. Fla., H 2455; Eustis, N 1517; Sugar Loaf Key, P 63; ——, Swingle.
1690. **Pinus palustris,** Mill. Lake City, R 480, H 2458; Duval county, C 2650; Eustis, N 408.
1691. **Juniperus virginiana,** L. Suwanee county, H 2446; Archer, R 481; Hernando county, H 2447; Clearwater, R 706; Palmetto, N 2454; Manatee, S 95.
1692. **Chamaecyparis sphaeroides,** Spach. Eustis, H 2448.
1693. **Taxodium distichum,** Rich. Jefferson county, H 2444; Suwanee county, H 2443; Lake City, R 704, H 2441; Duval county, C 5789, 5828; Eustis, N 716, H 2439, 2440; New River, H 2442, 2445.
1694. **Taxus floridana,** Nutt. Aspalaga, C 2674.
1695. **Torreya taxifolia,** Arn. Chattahoochee, N 2381, C 2675.

CYCADACEAE.

1696. **Zamia integrifolia,** Jacq. Alachua county, H 2392 (I observed this first about ten miles north of Archer); Archer, R 702, 497; Daytona, C 2676; Cocoanutgrove, H 2393.

FILICES.

1697. **Acrostichum aureum,** L. Indian River, C 3660; Hernando county, H 2400; Palm Beach, W 242, H 2399; Arch Creek, C 5463; Miami, R 946.
1698. **Polypodium plumula,** Willd. Sewell's Point, C 5861.

1699. **Polypodium incanum,** Sw. Columbia county, H 2436; Lake City, R 747; Citrus county, H 2437; Istachatta, C 5972; Eustis, N 876, H 2438; Palm Beach, H 2435; Miami, P 270; Pasco county, B 2631.

1700. **Polypodium phyllitidis,** L. Indian River Narrows, C 3668; Palm Beach, C 5402; New River, W 290; Lemon City, H 2433, 2434; Key Largo, P 204.

1701. **Polypodium aureum,** L. Daytona, R 836; Jupiter Inlet, C 5550; Eustis, N 1500; Palmetto, R 754, 755; Halifax River, C 3669.

1702. **Vittaria lineata,** R. Br. Eustis, N 1503, H 2397; Jupiter Inlet, C 5551; Lemon City, H 2398; Miami, P 238; Halifax River, C 3710; Clearwater, R 835.

1703. **Pteris longifolia,** L. Biscayne Bay, C 3703, 5490; Miami, P 271; Cocoanutgrove, H 2420; Sugar Loaf Key, P 64.

1704. **Pteris cretica,** L. Aspalaga, C 3705; Columbia county, H 2414; Istachatta, C 5967.

1705. **Pteris aquilina,** L. Jefferson county, H 2417; Lake City, H 2416; Duval county, H 2583; Eustis, N 638, H 2419; Polk county, R 751; Palm Beach, H 2418; var. **caudata,** Cape Sable, C 3705*; Sugar Loaf Key, P 43.

1706. **Adiantum tenerum,** Sw. Istachatta, C 5961; Hernando county, C 3709*.

1707. **Adiantum capillus-veneris,** L. Aspalaga, C 3709; Columbia county, H 2432.

1708. **Ceratopteris thalictroides,** Brongn. Istachatta, C 5973; head waters of St. John's River, C 3690*.

1709. **Blechnum serrulatum,** Michx. Lake City, R 1272; Eustis, N 884, H 2395, 2396; Winter Park, R 1264; Winter Haven, R 745; Mosquito Lagoon, C 3711; Palm Beach, C 5397, H 2394; Jensen, C.

1710. **Woodwardia angustifolia,** Smith. Jefferson county, H 2430; Lake City, R 756, 998, 999, H 2431; Archer, R 1204 in part; McClenny, C 5977; Eustis, N 1636.

1711. **Woodwardia virginica,** Willd. Jefferson county, H 2428; Madison county, H 2427; Lake City, R 753, 1198; Eustis, N 658, H 2429; Polk county, R 752, 1371.

1712. **Asplenium dentatum,** L. Biscayne Bay, C 3723; Palm Beach, H 2414; Arch Creek, C 5461.

1713. **Asplenium ebeneum,** Ait. Jefferson county, H 2408; Columbia county, H 2410; Lake City, R 746, 997, 1098, 1102, 1109, H 2409; Archer, R 1204; Eustis, N 977, H 2411.

1714. **Asplenium parvulum,** M. & G. Aspalaga, C 3720*; Istachatta, C 5966; Columbia county, H 2412.

1715. **Asplenium firmum,** Kunze. Lake Tsala Apopka, C 3723*; Istachatta, C 5962.

1716. **Asplenium myriophyllum,** Presl. Lake Tsala Apopka, C 3728; Istachatta, C 5963; Columbia county, H 2413.

1717. **Asplenium felix-fœmina,** Bernh. Lake City, R 749, 1000, N 2236.

1718. **Aspidium thelypteris,** Sw. Suwanee county, H 2406; Columbia county, H 2407; Eustis, H 2405.

1719. **Aspidium patens,** Sw. Lake City, R 748, H 2404; Eustis, N 861; New River, H 2403.

1720. **Aspidium unitum,** var. **glabrum,** Met. Eustis, N 1029.

1721. **Aspidium floridanum,** Eaton. Lake City, R 744; Eustis, N 773.

1722. **Aspidium acrostichoides,** Sw. River Junction, N 2387.
1723. **Aspidium trifoliatum,** Sw. Lake Tsala Apopka, C 3752*; Istachatta, C 5964.
1724. **Nephrolepis exaltata,** Schott. Eustis, N 1288; Indian River, C 3760; Clearwater, R 750, 834; Palm Beach, W 218, H 2402; Arch Creek, C 5460.
1725. **Phegopteris reptans,** Eaton. Istachatta, C 5965.
1726. **Aneima adiantifolia,** Sw. Biscayne Bay, C 3770; Lemon City, H 2401; No Name Key, P 112, C 5512.
1727. **Osmunda regalis,** L. Jefferson county, H 2423; Lake City, R 743, 1097, 1202, H 2426; Palm Beach, H 2424; Lemon City, H 2425; Pasco county, B 2095.
1728. **Osmunda cinnamomea,** L. Jefferson county, H 2422; Lake City, R 757, 1001, 1096, 1105, 1110, 1200, 1201, H 2421; Eustis, N 274.

Additions to Part I.

Names in bold-faced type are additional species; others are additional localities, or specimens.

CLEMATIS BALDWINII, T. & G. San Antonio, B 2704.
CLEMATIS RETICULATA, Walt. Johnson, B 2135.
CLEMATIS CRISPA, L. C, May 22 (1896).
Ranunculus parviflorus, L. River Junction, C 6400.
ILLICIUM FLORIDANUM, Ellis. Walton county, C 6378.
MAGNOLIA GRANDIFLORA, L. Manatee, S 42.
ASIMINA PARVIFLORA, Dunal. Duval county, H 2584; Manatee, S 1.
ASIMINA GRANDIFLORA, Dunal. Duval county, C 6358, H 2585.
ASIMINA OBOVATA, Nash. Jessamine, B 2524.
ASIMINA CUNEATA, Shuttlw. Eau Gallie, C, March 21 (1896); Chipco, B 2515; Manatee, S 16.
ANONA LAURIFOLIA, Dunal. Arch Creek, C, July 8 (1896).
COCCULUS CAROLINUS, DC. Chattahoochee, C, July 13 (1897).
NUPHAR SAGITTÆFOLIUM, Pursh. Milton, C 6409.
SARRACENIA PSITTACINA, Michx. Walton county, C 6384.
ARGEMONE MEXICANA, L. Tampa, B 2234.
Arabis ludoviciana, Meyer. Chattahoochee, C, May 4 (1898).
Sisymbrium canescens, Nutt. Jessamine, B 2636.
LEPIDIUM VIRGINICUM, L. Duval county, H 2586.
SENEBIERA PINNATIFIDA, DC. St. Augustine, C 6364.
HELIANTHEMUM CORYMBOSUM, Michx. Duval county, C 4604, H 2587; Blanton, B 2652.
HELIANTHEMUM GEORGIANUM, Chapm. River Junction, C 6392.
LECHEA TENUIFOLIA, Michx. Duval county, C 5026.
LECHEA PATULA, Leggett. Jessamine, B 2626.
Viola vicinalis, Greene. Jessamine, B 2647.
VIOLA INSIGNIS, Pollard. Chipco, B 2503.
VIOLA PRIMULÆFOLIA, L. Chipco, B 2502.
SILENE ANTIRRHINA, L. Jessamine, B 2672.
ARENARIA CAROLINIANA, Walt. Walton county, C 6386.
STIPULICIDA SETACEA, Michx. Johnson, B 2125.
Sagina decumbens, T. & G. Duval county, C 6353.
MOLLUGO VERTICILLATA, L. Duval county, C 4688.

PORTULACA PILOSA, L. Duval county, H 2589.
ASCYRUM HYPERICOIDES, L. Manatee, S 93.
ASCYRUM AMPLEXICAULE, Michx. Jessamine, B 2677.
HYPERICUM FASCICULATUM, Lam. Johnson, B 2056.
HYPERICUM GALIOIDES, Lam. Ponce de Leon, C 6483.
HYPERICUM OPACUM, T. & G. Lake Butler, B 2745.
HYPERICUM MUTILUM, L. Jessamine, B 2551.
HYPERICUM GYMNANTHUM, E. & G. Duval county, H 2590.
GORDONIA LASIANTHA, L. Duval county, C 4884; Manatee, S 50.
Malvastrum tricuspidatum, Gray. St. Augustine, C 6421.
SIDA ACUTA, Burm. Alachua county, B 2035.
SIDA RUBRA-MARGINATA, Nash. St. Augustine, C 6423; Duval county, H 2592.
ABUTILON PEDUNCULARE, HBK. Key West, C, April (1896).
MELOCHIA CORCHIFOLIA, L. Duval county, C 6511.
Kosteletzkya virginica, Presl. Duval county, H 5591.
TRIBULUS MAXIMUS, L. St. Augustine, C 6424.
OXALIS CORNICULATA, L., var. DILLENII, Trel. Jessamine, B 2650.
OXALIS FILIPES, Small. Duval county, B 2009, H 2593.
PTELEA TRIFOLIATA, L. Jessamine, B 2664; Duval county, C 4689.
XANTHOXYLUM CLAVA-HERCULES, L. Duval county, H 2594; Manatee, S 10.
RHUS COPALLINA, L. Manatee, S 51.
ILEX OPACA, Ait. Duval county, C 1744, 6359, H 2596.
ILEX CASSINE, L. Manatee, S. 27.
ILEX AMBIGUA, Chapm. Jessamine, B 2671.
ILEX GLABRA, Gray. Sutherland, B 2760; Manatee, S 20.
ILEX CORIACEA, Chapm. Jessamine, B 2543.
Ilex decidua, Walt. Chattahoochee, C 6341.
CLIFTONIA NITIDA, Gærtn. De Funiak, C 6381.
XIMENIA AMERICANA, L. Manatee, S 66.
EUONYMUS AMERICANUS, L. Jessamine, B 2665.
BERCHEMIA VOLUBILIS, DC. Manatee, S 21.
SAGERETIA MICHAUXII, Brongn. Manatee, S 19.
CEANOTHUS AMERICANUS, var. INTERMEDIUS, Trel. Johnson, B 2081.
CEANOTHUS MICROPHYLLUS, Michx. Jessamine, B 2691.
VITIS ROTUNDIFOLIA, Michx. Manatee, S 35.
VITIS MUNSONIANA, Simp. Duval county, H 2595; Manatee, S 34.
VITIS ÆSTIVALIS, Michx. Manatee, S 37.
VITIS CARIBÆA, DC. Duval county, C 6415.
CISSUS STANS, Pers. Manatee, S 36.
ÆSCULUS PAVIA, L. River Junction, C 6367.
POLYGALA GRANDIFLORA, Walt. Palm Beach, C May (1896), var. ANGUSTIFOLIA, T. & G. Sutherland, B 2743.
POLYGALA BOYKINII, Nutt. Ybor City, B 2207.
POLYGALA INCARNATA, L. Sutherland, B 2732; Seaside, B 2764.
POLYGALA LEPTOSTACHYS, Shuttl. Duval county, C 4887.
POLYGALA SETACEA, Michx. Ozona, B 2733.
POLYGALA NANA, DC. Sutherland, B 2765.
POLYGALA LUTEA, L. Johnson, B 2152.
POLYGALA RUGELII, Shuttl. Sutherland, B 2728.
POLYGALA CYMOSA, Walt. Pasco, B 2707.

POLYGALA RAMOSA, Ell. Cross Bayou, B 2772.
POLYGALA BALDWINII, Nutt. Cross Bayou, B 2775.
Polygala brevifolia, Nutt. De Funiak, C, June 25 (1897).
Polygala hookeri, T & G. Argyle, C 6485.
CROTALARIA OVALIS, Pursh. Jessamine, B 2689½.
CROTALARIA PURSHII, DC. Sutherland, B 2725.
LUPINUS DIFFUSUS, Nutt. Jessamine, B 2523.
Medicago minima, L. Anastatia, C, April 17 (1896).
TRIFOLIUM REPENS, L. Duval county, H 2601.
TRIFOLIUM CAROLINIANUM, Michx. Chattahoochee, C 6377.
PSORALEA CANESCENS, Michx. Alachua county, B 2042.
PSORALEA LUPINELLUS, Michx. Johnson, B 2079.
AMORPHA FRUTICOSA, L. Duval county, C 6410, H 2598.
WISTARIA FRUTESCENS, DC. Duval county, C 4648.
TEPHROSIA SPICATA, T. & G. Duval county, C 6419.
Tephrosia intermedia, Small. Duval county, C 4825.
SESBANIA MICROCARPA, Muhl. Duval county, H 2600.
ASTRAGALUS OBCORDATUS, Ell. Jessamine, B 2637.
ASTRAGALUS VILLOSUS, Michx. Duval county, C, March 17 (1894).
VICIA ACUTIFOLIA, Ell. Ybor City, B 2208.
ÆSCHYNOMENE HISPIDA, Willd. Duval county, H 2597.
ÆSCHYNOMENE VISCIDULA, Michx. Sutherland, B 2762.
ZORNIA TETRAPHYLLA, Michx. Sutherland, B 2751.
STYLOSANTHES ELATIOR, Sw. Duval county, C 6418; Sutherland, B 2780; Johnson, B 2011.
Desmodium rotundifolium, DC. River Junction, C, September 9 (1897).
Desmodium lineatum, DC. Duval county, C 5255.
Desmodium rigidum, DC. Johnson, B 2175.
DESMODIUM TRIFLORUM, DC. Alachua county, B 2045.
RHYNCHOSIA MINIMA, DC. Duval county, C 5600.
RHYNCHOSIA MENISPERMOIDES, DC. Sutherland, B 2726.
ERYTHRINA HERBACEA, L. Manatee, S 46.
CENTROSEMA VIRGINIANA, Benth. Duval county, C 5172; Johnson, B 2177.
GALACTIA ERECTA, Vail. Argyle, C 6487.
GALACTIA MOLLIS, Michx. Duval county, C, June 12 (1896).
GALACTIA ELLIOTTII, Nutt. Duval county, H 2599.
ECASTOPHYLLUM BROWNEI, Pers. Manatee, S 35.
BAPTISIA LANCEOLATA, Ell. De Funiak, C 6379.
BAPTISIA LECONTEI, T. & G. Jessamine, B 2186.
BAPTISIA CALYCOSA, Canby. Crest View, C 6406.
SOPHORA TOMENTOSA, L. Palma Sola, S 81.
CASSIA OCCIDENTALIS, L. Duval county, C 5212.
KRAMERIA LANCEOLATA, Torr. Keystone Station, B 2783.
Gleditschia monosperma, Walt. Manatee, S 29.
PRUNUS SEROTINA, Ehrh. Duval county, H 2602.
PRUNUS CAROLINIANA, Ait. Manatee, S 4.
RUBUS TRIVIALIS, Michx. Duval county, H 2603; Jessamine, B 2520.
CRATÆGUS SPATHULATA, Michx. River Junction, C 6349.
PYRUS ARBUTIFOLIA, L., var. ERYTHROCARPA, Chapm. Jessamine, B 2542.
ITEA VIRGINICA, L. Jessamine, B 2684.
HYDRANGEA QUERCIFOLIA, Bartr. Chattahoochee, C 6479.

DROSERA CAPILLARIS, Poir. Lake Butler, B 2746.
Drosera filiformis, Raf. Argyle, C 6404.
LIQUIDAMBAR STYRACIFLUA, L. Jessamine, B 2520.
CONOCARPUS ERECTA, Jacq., var. SERICEA, DC. Manatee, S 82, 84.
EUGENIA GARBERI, Sarg. C, July 10 (1896).
EUGENIA LONGIPES, Berg. No Name Key, C, May (1896).
EUGENIA AXILLARIS, Willd. Tampa, S 90.
RHEXIA MARIANA, L. Duval county, H 2604.
RHEXIA LANCEOLATA, Walt. San Antonio, B 2787.
LYTHRUM LINEARE, L. Duval county, H 2605.
PROSERPINACA PECTINACEA, Lam. St. Augustine, C, September 20 (1898); San Antonio, B 2702.
GAURA ANGUSTIFOLIA, Michx. Tampa, B 2759; Duval county, C 2609.
ŒNOTHERA SINUATA, L. River Junction, C 6371; Duval county, H 2608.
JUSSIÆA PERUVIANA, L. Manatee, S 54.
Jussiæa pilosa, HBK. Duval county, C 5308, 6539.
LUDWIGIA ALTERNIFOLIA, L. Duval county, H 2606.
LUDWIGIA VIRGATA, Michx. Duval county, H 2607.
LUDWIGIA ARCUATA, Walt. Jessamine, B 2552.
PIRIQUETA CAROLINIANA, Urb., var. GLABRA, Urb. Jessamine, B 2696; Johnson, B 2180.
Hydrocotyle canbyi, C. & R. Duval county, C 4964.
HYDROCOTYLE UMBELLATA, L. Jessamine, B 2544.
HYDROCOTYLE REPANDA, Pers. Duval county, H 2611.
Sanicula floridana, Bickn. Duval county, C 6417, 1994; Lake City, R 214, N 2244, H 730; Madison county, H 731.
ERYNGIUM YUCCÆFOLIUM, Michx., var. SYNCHÆTUM, Gray. Jupiter, C, September 6 (1895).
ERYNGIUM AROMATICUM, Baldw. Jessamine, B 2602.
ERYNGIUM BALDWINII, Spreng. Ybor City, B 2206.
CICUTA MACULATA, L. Duval county, H 2612.
LEPTOCAULIS DIVARICATUS, DC. Johnson, B 2056; Jessamine, B 2555.
DISCOPLEURA CAPILLACEA, DC. Duval county, H 2613.
ANGELICA DENTATA, Chapm. Chattahoochee, C, July (1897).
Cornus stricta, Lam. Manatee, S 17; Duval county, C 4708; Chattahoochee, C 6396; Eustis, H 732.
SAMBUCUS CANADENSIS, L. Manatee, S 45.
Viburnum cassinoides, L. Duval county, C 4556.
VIBURNUM NUDUM, L. Jessamine, B 2528, 2529.
VIBURNUM OBOVATUM, Walt. Duval county, C 6398; Manatee, S 6.
LONICERA SEMPERVIRENS, Ait. River Junction, C 6375.
OLDENLANDIA GLOMERATA, Michx. Sutherland, B 2731.
HAMELIA PATENS, Jacq. Manatee, S 48.
CEPHALANTHUS OCCIDENTALIS, L. Duval county, H 2615; Manatee, S 39.
GUETTARDA ELLIPTICA, Sw. Key Largo, C, July 26 (1896).
MITCHELLA REPENS, L. Duval county, C 4655.
RICHARDIA SCABRA, L. Sutherland, B 2750.
Spermacoce portoricensis, Balbis. Key West, C 1111. (No. 523 of part I.)
DIODIA HIRSUTA, Pursh. St. Augustine, C 6425.
DIODIA TERES, Walt. Duval county, H 2614.
GALIUM PILOSUM, Ait., var. PUNCTICULOSUM, Gray. Duval county, C 6420.

EUPATORIUM ROTUNDIFOLIUM, L. St. Augustine, C 6428.
EUPATORIUM AROMATICUM, L. Duval county, C 6432; Jessamine, B 2612.
CHRYSOPSIS GRAMINIFOLIA, Ell. Jessamine, B 2610.
CHRYSOPSIS SCABRELLA, T. & G. Jessamine, B 2609.
CHRYSOPSIS TRICHOPHYLLA, Nutt. Sutherland, B 2741.
CHRYSOPSIS GOSSYPINA, Nutt. Jessamine, B 2629.
Aplopappus rubiginosus, T. & G., var. **phyllocephalus,** Gray. Palmetto, N 2432; Pensacola, C 6494. (No. 586 of part I.)
BIGELOVIA NUDATA, DC. Hillsboro county, B 2774.
SOLIDAGO BOOTTII, Hook. Duval county, C 6537.
Aster squarrosus, Walt. Duval county, C 5352.
Aster divaricatus, T. & G., var. **graminifolius,** Baker. Pensacola, C 6497.
Aster diffusus, Ait. Duval county, C, November (1894).
ASTER CAROLINIANUS, Walt. Manatee, S 94.
ASTER CONCOLOR, L. Duval county, C 6434.
ASTER RETICULATUS, Pursh. Jessamine, B 2080.
ERIGERON NUDICAULIS, Michx. Chipco, B 2655.
Erigeron bonariensis, L. Pensacola, C 6499.
BACCHARIS HALIMIFOLIA, L. Manatee, S. 96.
BACCHARIS ANGUSTIFOLIA, Michx. Manatee, S 63.
GNAPHALIUM PURPUREUM, L. Duval county, C 4615; Jessamine, B 2638. Narrow-leaved form, Jessamine, B 2639.
ACANTHOSPERMUM HUMILE, DC. Pensacola, C 6501.
ACANTHOSPERMUM XANTHIOIDES, DC. Alachua county, B 2044.
IVA FRUTESCENS, L. St. Augustine, C 6457.
AMBROSIA ARTEMISIÆFOLIA, L. Duval county, H 2616.
ECLIPTA ALBA, Hook. Duval county, H 2618; Tampa, B 2194.
Pascalia glauca, Orteg. Pensacola, C 6492.
VERBESINA VIRGINICA, L. Duval county, C 6544.
COREOPSIS LEAVENWORTHII, T. & G. Pasco county, B 2715.
Coreopsis coronata, Hook. St. Augustine, C 6362.
COREOPSIS LANCEOLATA, L., var. VILLOSA, Michx. River Junct., C 6390.
BALDWINIA MULTIFLORA, Nutt. Jessamine, B 2608.
PALAFOXIA FEAYI, Gray. Melbourne, C, July (1896); Braidentown, S 61.
HELENIUM VERNALE, Walt. Pasco county, B 2711.
Helenium brevifolium, Gray. De Funiak, C 6383.
HELENIUM NUTTALLII, Gray. De Funiak, C 6382.
FLAVERIA REPANDA, Lag. Pensacola, C 6495. (No. 695 of part I.)
SENECIO LOBATUS, Pers. River Junction, C 6370.
CACALIA FLORIDANA, Gray. Duval county, C 6416; Tampa, B 2198.
CNICUS NUTTALLII, Gray. Duval county, H 2617.
Apogon humilis, Ell. Chattahoochee, C 6395.
Krigia dandelion, Nutt. Jessamine, B 2640.
HIERACEUM GRONOVII, L. Duval county, C 6430.
LACTUCA GRAMINIFOLIA, Michx. Duval county, H 2617.
Prenanthes virgata, Michx. Duval county, C 5324.
Specularia biflora, Gray. River Junction, C 6372.
LOBELIA CLIFFORTIANA, L., var. XALAPENSIS, Gray. Jessamine, B 2536; St. Augustine, C 6363.
LOBELIA FEAYANA, Gray. Hillsboro county, B 2753.
SPECULARIA PERFOLIATA, A. DC. Jessamine, B 2642, 2649.

GAYLUSSACIA DUMOSA, T. & G. Duval county, C 6360; De Funiak, C 6388.
GAYLUSSACIA FRONDOSA, T. & G. Duval county, C 6350.
VACCINIUM ARBOREUM, Michx. Jessamine, B 2560; Manatee, S 62.
VACCINIUM STAMINEUM, L. Jessamine, B 2546.
VACCINIUM MYRSINITES, Michx. Duval county, C 5827; Manatee, S 7; Pasco county, B 2514.
VACCINIUM CORYMBOSUM, L., var. FUSCATUM, Gray. Manatee, S 8.
ANDROMEDA NITIDA, Bartr. Manatee, S 2.
ANDROMEDA FERRUGINEA, Walt. Jessamine, B 2540.
ANDROMEDA FRUTICOSA. Manatee, S 31.
AZALEA NUDIFLORA, L. Chattahoochee, C 6373.
BEJARIA RACEMOSA, Vent. Manatee, S 41.
SAMOLUS FLORIBUNDUS, HBK. Hillsboro county, B 2209.
SAMOLUS EBRACTEATUS, HBK. Hillsboro county, B 2724.
MYRSINE RAPANEA, R. & S. Manatee, S 73.
ARDISIA PICKERINGII, T. & G. Manatee, S 71.
BUMELIA TENAX, Willd. Manatee, S 44.
BUMELIA LYCIOIDES, Gærtn., var. RECLINATA, Gray. Manatee, S 44 in part.
DIOSPYROS VIRGINIANA, L. Manatee, S 30.
Styrax grandifolia, Ait. Duval county, C 6546.
Styrax americana, Lam. De Funiak, April 29 (1898).
STYRAX PULVERULENTA, Michx. Duval county, C 6357.
FRAXINUS EPIPTERA, Michx. Duval county, C 4536.
FRAXINUS CUBENSIS, Griseb. Manatee, S 18.
CHIONANTHUS VIRGINICA, L. Manatee, S 43; Jessamine, B 2519; Crest View, C, May 11 (1898).
Osmanthus floridanus, Chapm. Manatee, S 9.
ANANTHERIX CONNIVENS, Gray. Apalachicola, C June 12 (1897).
ASCLEPIODORA VIRIDIS, Gray. River Junction, C 6389.
ASCLEPIAS PAUPERCULA, Michx. Pasco county, B 2782.
ASCLEPIAS OBTUSIFOLIA, Michx. Jessamine, B 2686.
ASCLEPIAS AMPLEXICAULIS, Michx. Jessamine, B 2535, 2557.
ASCLEPIAS VERTICILLATA, L. Alachua county, B 2040.
ASCLEPIAS ANGUSTIFOLIA, Ell. Duval county, C 4724.
ASCLEPIAS FEAYI, Gray. Pasco county, B 2717.
Acerates longifolia, Ell. Lake City, R 729. (No. 810 of part I.)
VINCETOXICUM SCOPARIUM, Gray. Manatee, S 53.
GELSEMIUM SEMPERVIRENS, Ait. Manatee, S 5, 5*a*; Jessamine, B 2518.
SABBATIA GRACILIS, Salisb. Duval county, H 2619; Bonifay, C 6481.
SABBATIA GENTIANOIDES, Ell. Argyle, C 6484.
BARTONIA VERNA, Muhl. Pasco county, B 2301.
LIMNANTHEMUM TRACHYSPERMUM, Gray. Jessamine, B 2659.
PHLOX FLORIDANA, Benth. Jessamine, B 2682.
PHLOX DRUMMONDII, Hook. Duval county, H 2618.
HELIOTROPIUM POLYPHYLLUM, Lehm. Hillsboro county, B 2767.
Var. LEAVENWORTHII, Gray. New River, C, May (1897).
LITHOSPERMUM HIRTUM, Lehm. Crest View, C 6408.
LITHOSPERMUM TUBEROSUM, Rugel. Chattahoochee, C 6374.
ONOSMODIUM VIRGINIANUM, DC. Jessamine, B 2548, 2678.
Ipomœa hederacea, Jacq., var. **integriuscula,** Gray. Duval county, C 6529.

Ipomœa palmata, Forst. Pensacola, C 6496.
Ipomœa jalapa, Pursh. St. John's River, C, Sept. (1897).
IPOMŒA SAGITTATA, Cav. Duval county, H 2620.
IPOMŒA SINUATA, Ort. Duval county, C 6538.
IPOMŒA ACETOSAEFOLIA, R. Br. Duval county, C 6545.
EVOLVULUS SERICEUS, Sw. Jessamine, B 2689.
SOLANUM NIGRUM, L., var. VILLOSUM, Mill. Pensacola, C 6493.
PHYSALIS ARENICOLA, Kearney. Pasco county, B 2687.
CAPSICUM FRUTESCENS, L. Tampa Bay, S 86.
LYCIUM CAROLINIANUM, Michx. Duval county, C 6543.
DATURA TATULA, L. Hillsboro county, B 2736.
Nicotiana longiflora, Cav. Pensacola, C 6491.
PENTSTEMON PUBESCENS, Sol. Pasco county, B 2654; Duval county, C, May 22 (1896).
HERPESTIS NIGRESCENS, Benth. Hillsboro county, B 2757.
HERPESTIS AMPLEXICAULIS, Pursh. Rockledge, C, August 1 (1896).
HERPESTIS MONNIERA, HBK. Hillsboro county, B 2722; Duval county, H 2621.
GRATIOLA SUBULATA, Baldw. Putnam county, B 2168.
ILYSANTHES GRANDIFLORA, Benth. Pasco county, B 2505.
MICRANTHEMUM ORBICULATUM, Michx. Duval county, C 6552*a*; St. Augustine, C 6552.
SCOPARIA DULCIS, L. Hillsboro county, B 2217.
Scoparia flava, C. & S. Carabelle, C, June 8 (1897).
BUCHNERA ELONGATA, Sw. Pasco county, B 2699.
Schwalbea americana, L. Duval county, C 4722.
UTRICULARIA INFLATA, Walt. Hillsboro county, B 2734; Duval county, C 4564.
UTRICULARIA OLIGOSPERMA, St. Hil. Hillsboro county, B 2771.
UTRICULARIA MACRORHIZA, Barnh. Pasco county, B 2641.
UTRICULARIA SUBULATA, L. Pasco county, B 2506.
UTRICULARIA CORNUTA, Michx. Pasco county, B 2706.
Pinguicula planifolia, Chapm. Crest View, C, May 11 (1898).
PINGUICULA PUMILA, Michx. Pasco county, B 2662.
PINGUICULA ELATIOR, Michx. Pasco county, B 2510.
CALOPHANES OBLONGIFOLIA, Don. Pasco county, B 2680.
RUELLIA CILIOSA, Pursh. Pasco county, B 2666; Crest View, C 6489.
Verbena bonariensis, L. Pensacola, C 6490.
LANTANA INVOLUCRATA, L. Tampa Bay, S 75.
LANTANA CAMARA, L. Manatee, S 23.
CALLICARPA AMERICANA, L. Duval county, H 2622; Manatee, S 40.
AVICENNA NITIDA, Jacq. Manatee, S 80; Key West, C, May 2 (1896).
SATUREIA RIGIDA, Bartr. Pasco county, B 2710, 2786.
MICROMERIA BROWNEI, Benth. Chattahoochee, C 6398.
SALVIA COCCINEA, L. Putnam county, B 2065.
MONARDA PUNCTATA, L. Pasco county, B 2616.
STACHYS FLORIDANA, Shuttl. Pasco county, B 2670, 2672½.
Plantago heterophylla, Nutt. Chattahoochee, C 6399.
Plantago major, L. Duval county, C 5041.
PLANTAGO VIRGINICA, L. Duval county, C 6351.
MIRABILIS JALAPA, L. Duval county, C 6541.
SIPHONYCHIA AMERICANA, T. & G. Pasco county, B 2605.

Amarantus albus, L. River Junction, C 6480.
AMARANTUS HYBRIDIS, L. Duval county, C 4982.
ACNIDA TAMARASCINA, Wood., var. PROSTRATA, U. and B. Sarasota Key, C 2373.
Telanthera phylloxeroides, Moq., var. **acutifolia,** Moq. Carabelle, C, June 9 (1897).
RIVINA HUMILIS, L. Manatee, S 77.
PHYTOLACCA DECANDRA, L. Duval county, H 2624.
RUMEX FLORIDANUS, Meisn. Duval county, H 2627.
RUMEX HASTATULUS, Baldw. Duval county, H 2626.
POLYGONELLA PARVIFOLIA, Michx. Manatee, S 52.
POLYGONELLA GRACILIS, Meisn. Duval county, C 5329; Pasco county, B 2604.
POLYGONUM HYDROPIPEROIDES, Michx. Duval county, H 2625.
POLYGONUM HIRSUTUM, Walt. Duval county, C, August 13 (1896).
POLYGONUM AVICULARE, L. Apalachicola, C, June 11 (1897).
ERIOGONUM TOMENTOSUM, Michx. Pasco county, B 2607.
ARISTOLOCHIA TOMENTOSA, Sims. Chattahoochee, C 6394.
ARISTOLOCHIA NASHII, Kearney. Duval county, C 4993.
SAURURUS CERNUUS, L. Duval county, H 2628; Putnam county, B 2092.
PERSEA CAROLINENSIS, Nees. Manatee, S 32.
PERSEA PUBESCENS, Sarg. Manatee, S 33.
NECTANDRA WILLDENOVII, Nees. Miami, C, July 12 (1896).
EUPHORBIA PILULIFERA, L. Palm Beach, C, May (1896).
EUPHORBIA ADENOPTERA, Bertol. Miami, C, July (1896).
Euphorbia prostrata, Ait. St. Augustine, C 6426.
Euphorbia brasiliensis, Lam. Miami, C, July 10 (1895).
ACALYPHA CAROLINIANA, Walt. St. Augustine, C 6456.
Tragia macrocarpa, Willd. Chattahoochee, C 6478.
TRAGIA LINEARIFOLIA, Ell. Pasco county, B 2693.
CROTON MARITIMUS, Walt. Manatee, S 83.
CROTON CAPITATUS, Michx. Pensacola, C 6498.
CROTON GLANDULOSUS, L. Hillsboro county, B 2197.
CNIDOSCULUS STIMULOSUS, Gray. Pasco county, B 2669.
URTICA URENS, L. St. Augustine, C 6365.
BOEHMERIA CYLINDRICA, Willd., var. SCABRA, Port. Duval county, H 2629.
MYRICA CERIFERA, L. Manatee, S 14.
Var. PUMILA, S 3.
Var. **media,** Michx. Duval county, C 4591.
PHORADENDRON FLAVESCENS, Nutt. Manatee, S 49.
CARYA PORCINA, Nutt. Duval county, H 2630.
QUERCUS PHELLOS, L. Manatee, S 13; Duval county, H 2631.
Quercus minima, Small. Duval county, C 6432.
QUERCUS CINEREA, Michx. Manatee, S 58.
QUERCUS AQUATICA, Walt. Manatee, S 59, 64.
QUERCUS CATESBÆA, Michx. Manatee, S 56. Catesbæa × cinerea, Manatee, S 55.
QUERCUS MYRTIFOLIA, Willd. Manatee, S 28. Myrtifolia × stellata, Manatee, S 68.
QUERCUS PUMILA, Walt. Manatee, S 15; Duval county, C 6361.
QUERCUS PARVIFOLIA, Small. Manatee, S 69.
QUERCUS VIRENS, Ait. St. Augustine, C 6427; Manatee, S 11, 22, 57, 65.

CASTANEA PUMILA, Michx. Duval county, C 6411.
CERATIOLA ERICOIDES, Michx. Manatee, S 67; Hillsboro county, B 2744.
CERATOPHYLLUM DEMERSUM, L. Duval county, C 5173.
APTERA SETACEA, Nutt. Pasco county, B 2621.
Microstylis floridana, Chapm. Istachatta, C (1897).
BLETIA VERECUNDA, Sw. No Name Key, C, April 22 (1896).
CALOPOGON PARVIFLORUS, Lindl. Pasco county, B 2526.
Calopogon multiflorus, Lindl. Eau Gallie, C, March 21 (1896).
Cyrtopodium ecristatum, Fernald. Eau Gallie, C, July (1896).
POGONIA OPHIOGLOSSOIDES, Nutt. Marion county, B 2033.
POGONIA DIVARICATA, R. Br. Duval county, C 4729.
HABENARIA REPENS, Nutt. Eau Gallie, C, July (1896).
ZEPHYRANTHES TREATIÆ, Wats. Duval county, C 6347.
PANCRATIUM ROTATUM, Ker. Duval county, C 4732.
HYPOXIS JUNCEA, Smith. Pasco county, B 2538.
TILLANDSIA RECURVATA, Pursh. Duval county, C 5054.

NATIVE PLANTS OF KANSAS ADAPTED TO CULTIVATION.

BY GRACE R. MEEKER, OTTAWA, KAN.

Read before the Academy December 29, 1900.

Kansas is centrally located, dividing north from south and east from west. The elevation of the surface varies, rising rapidly westward. The climate also varies, from drought a part of the year to drought all of the year. All these factors combine in the production of a varied flora. You will almost need a new botany for the western plains; and many plants of the southern or northern parts of the state are not known in the central portion. In all its different parts Kansas has many attractive plants. Some have already been introduced into other localities than their "native heath"; but much remains to be done before their decorative possibilities shall have been made known to us. It is not intended here to give a list of the wild flowers which are to be improved by cultivation, but those not likely to become pests, and whose pretty blossoms or fine foliage will repay your trouble. In western Kansas we have some desirable Compositæ. *Aster grandiflorus*, the largest-flowered aster of the plains, with brilliant blue or purple flowers, has been grown successfully from seed. Two gaillardias—*Gaillardia pulchella* and *G. lanceolata*—are highly recommended. Both gaillardias have flowers of good size, with bright brown centers, and rays—in *G. pulchella* purplish, in *G. lanceolata* yellow. The townsendias, of which we have two species, and *Zinnia grandiflora*, from the southwest, are also desirable. Beside these, we may add *Malvastrum coccineum*, the red mallow, which has been recommended to you by Miss Reed; *Mentzelia nuda;* and the *Yucca filamentosa*, whose beauty is not spoiled by its common name, soapweed, and which is often seen in Franklin county lawns. The mentzelia has large, creamy flowers, with a peculiar fringe of sterile filaments surrounding the fertile stamens. The plant itself is rough and somewhat coarse looking; but when the great creamy buds expand, as they do in the late afternoon, the plant is glorified.

From the south we get a handsome blossom, the *Dodecatheon meadia*, variously called wild cyclamen (which it resembles in shape of flower), shooting star, and American cowslip. This plant bears out the description of the botany —"very handsome in cultivation."

Of Franklin county plants with which I am most familiar, I have made a somewhat extended list to choose from.

Uvularia perfoliata (bellwort). A slender-stemmed plant, with nodding yellow flowers.

Polemonium reptans (Greek valerian). This plant has pretty pinnate leaves. Flowers light blue, bell shaped.

Trillium erectum. Plant a foot high. Flowers white, sometimes greenish, pink, or purple. This is, I believe, the only trillium found in Kansas. All members of the family are beautiful and are successfully cultivated in the East. For a common name the prettiest is the "wake robin."

Geranium maculatum (wild cranesbill). This plant has palmate leaves and pale purple flowers. It seems to take very kindly to Kansas soil.

LATE SPRING AND EARLY SUMMER FLOWERS.

Mertensia virginica (lungwort, bluebell, Virginia cowslip). A very handsome plant, which grows two feet high and has rich, blue-purple flowers. This plant grows in Kansas, in Franklin or Miami counties, where it has been introduced.

Cypripedium pubescens (yellow lady-slipper).

Cypripedium spectabile (showy lady-slipper). Flowers pink-purple. These two plants are terrestrial orchids, which I think would grow here, since we have the *Cypripedium parviflorum*, which florists consider one of the best.

Asarum canadense (wild ginger). A plant with very beautiful leaves. Flowers stemless and interesting.

Of early spring flowers, you will want the dog-tooth violets, *Erythronium mesochoreum* of the prairies and hillsides, and *Erythronium albidum* of the woods; the Dutchman's breeches, *Dicentra cucullaria*; the blood root, *Sanguinaria canadensis*; spring beauty, *Claytonia virginica* (this, I have been told, makes an elegant basket plant); all the violets, of which we have five species, including the wild pansy; the *Anemone caroliniana* and its near relation the *Isopyrum biternatum*. Golden *Corydalis* and chervil, *Chærophyllum peltatum*, seem worthy of a place here.

Sweet-william, *Phlox divaricata*, and prairie phlox, *Phlox pilosa*, the former with its lavender blossoms, which you will find in bloom in the woods by May 1, and the latter the pink phlox of the meadows, a little later in time of blooming, will add both color and fragrance to your garden. You will make room for the larkspur, *Delphinium tricorne*, blue, and *Delphinium carolinianum*, white, which I put together here, although the white bee larkspur belongs with summer bloomers.

The wild columbine, *Aquilegia canadensis*, with its bells of red and yellow, you will give a shady corner. The wild hyacinth, *Camassia frazeri*, and the common white mallow, *Callirhoe alcæoides*, will end the list of early spring flowers.

Of late spring and early summer flowers, we have *Penstemon cobea*, the wild foxglove, the most showy of its kind, which is sometimes given in seed catalogues; the evening primroses, yellow and white, *Œnothera missouriensis*, and *Œnothera speciosa;* the wild petunias, two species, the common *Ruellia ciliosa* of the prairies, and the more rare and more handsome *Ruellia strepens* of open woodlands. This last plant has the peculiarity of forming seed in closed blossoms, and is therefore but a shy bloomer; still, the blossoms are so handsome and the plant itself so "good looking" I venture to give it a place upon the list.

The spiderwort, *Tradescantia virginica*, no patriot will be without, for it

has red, white and blue forms. These, with the twin dayflower, *Commelyna*, are very desirable, responding readily to a little cultivation.

The false indigo, *Baptisia*, of which we have three species, cream color, white, and blue, are coarse and unworthy of cultivation, though often offered in catalogues.

The small-flowered lady-slipper, or moccasin flower, *Cypripedium parviflorum*, like all of its kind, hides away in unexpected places; and you may consider yourself most fortunate if you find any plants.

Asclepias tuberosa, the butterfly-weed, with orange-red flowers, and *Asclepias incarnata*, sometimes called the swamp milkweed, with red-purple flowers, will add a bright bit of color.

The golden ragwort, *Senecio aureus*, is a fine plant for decoration, keeping well when cut, and making a good blossom for corsage bouquets for the wearer of yellow.

St. John's-wort, *Hypericum*, of which we have two species, is another attractive flower; but be careful in cultivating this, lest you encourage a pest. The yellow coneflower, *Lepachys pinnata*, is a flower that I think is quite safe, and makes a fine growth in moderately rich soil.

SUMMER AND FALL FLOWERS.

Aconitum uncinatum (monkshood). Plant grows about two feet high; has dark-green palmate leaves and irregular, pale-blue flowers, which remind one strongly of the monk's hood, from which it takes it name.

Lonicera (honeysuckle) shrubs. Several species.

Aster novæ-angliæ (New England aster). A stout, shrub-like herb, with rather dark-blue flowers. Grows in rich, damp soil.

Aster sericeus. Leaves silky; flowers dark purple.

The wild red lily, *Lilium superbum*, is described by its name, a superb lily.

The sensitive brier or sensitive rose, *Schrankia uncinata*, with its near relation, the partridge pea, *Cassia chamæcrista*, will delight the children with their shrinking leaves and the peculiar way in which they go to sleep at night. It is probably the *Schrankia* to which Longfellow referred when he wrote, in Evangeline:

> "As at the tramp of a horse's hoof on the turf of the prairies,
> Far in advance are closed the leaves of the shrinking mimosa,
> So, at the hoof-beats of fate, with sad forebodings of evil,
> Shrinks and closes the heart ere the stroke of doom has attained it."

The horsemint, *Monarda fistulosa*, grows well in rich soil.

The jewel weed, or pale touch-me-not, *Impatiens pallida*, is very desirable; but needs shade and moisture, plenty of both.

In this division you will want the meadow rue, of which we have two species, *Thalictrum purpurascens* and *Thalictrum polygamum*. The last named has been considered worthy of illustration in "How to Grow Flowers." It grows tall, makes fine clumps of foliage, crowned with the mist-like, whitish clusters of delicate flowers. Needs a partially shady situation. The commoner meadow rue will grow almost anywhere in the garden, with the other woodland plants. The foliage is nice for cutting and adds very much to a cluster of roses.

Of the late summer and autumn flowers, we have *Euphorbia corollata*, flowering spurge. All the euphorbias are interesting to a botanist; the family is large, some members being tropical and cultivated in greenhouses. The button-snake-root and gay-feather species of *Liatris* are bright red-purple-flowered plants which, with the goldenrods and asters, sneeze-wort, *Helenium autumnale*, and the eupatoriums, make a good showing for the composite family.

The wild ageratum, *Eupatorium ageratoides*, you will find growing in moist, shady places with the asters. You will recognize it from its resemblance to the blue ageratum of the gardens. It is sometimes highly recommended for a companion to the scarlet salvia. If you can succeed in growing the cardinal flower, *Lobelia cardinalis*, the ageratum will go well with it. The blue *Lobelia syphilitica* is also desirable.

The blue gentian of our meadows, *Gentiana puberula*, is the crowning glory of our autumn fields. I know of nothing more beautiful than a cluster of these wonderfully blue flowers, which hide in the long grass of the prairie, often close to the roadside, and, when the sun shines brightly, open the petals to the fullest extent, closing tightly at night and on cloudy days. The flowers are very sensitive to light, often opening at night, if placed directly under the rays of a large lamp.

These flowers are due in the first weeks of October. You will find some by the 8th of that month, and with them I close this part of my list.

FERNS.

Our commonest fern is also one of the best for cultivation, the bladder fern, *Cystopteris fragilis*. We have also the maidenhair fern, *Adiantum pedatum;* the Christmas fern, *Aspidium acrostichoides;* the walking fern, *Camptosorus rhizophyllus*, and the moonwort, *Botrychium virginianum*, which is classed with ferns, although not one strictly speaking. There are some other ferns growing in the limestone ledges—the little cloak fern and the rock brake, which will need careful treatment in imitating their natural surroundings in order to do well.

Of vines, I hesitate which to put first. The Virginia creeper, *Ampelopsis quinquefolia*, seems to lead, with the climbing rose, *Rosa setigera*, a close second. Bitter-sweet, *Celastrus scandens;* the clematis, two species, *C. virginiana* and *C. pitcheri;* the wild cucumber, *Echinosystis lobata;* and the moonseed vine, *Menispermum canadense*, will give you quite a collection of native vines which have no objectionable features. I am tempted to add the passion-flower, native to the southern part of the state and the Indian territory and southward. The vine spreads from the root, but does not form seed in this climate. I must add the wild grape and the hop.

Of shrubs, you may select from button bush, *Cephalanthus occidentalis;* *Amorpha fruticosa* (the botany gives no common name—tall lead-wort will perhaps answer); sweet sumac, *Rhus aromatica*, which has attractive red berries; the sheepberry, nanny-berry, *Viburnum prunifolium*, which is sometimes called the black haw. The glossy, pear-like leaves make this one of our finest shrubs for decoration, even when not in bloom or fruit. Some of the cornels, dogwoods, might be used; and the *Staphylea trifolia*, or bladdernut, ought not to be left out.

For the water garden, you will want the water-lily, *Nelumbo lutea*, closely related to the lotus; the snow-head, *Sagittaria variabilis;* the water plantain, *Alisma plantago;* the bladderwort, *Utricularia vulgaris;* the water crowfoot, *Ranunculus multifidus*, with its golden flowers like a buttercup; the *Jussiæa*, with its shining leaves and yellow flowers; the water-willow, *Dianthera americana*, with its two-lipped white flowers, marked with purple; the little wild lantana or fog-fruit, *Lippia lanceolata*, and some plants of the cattail, *Typha latifolia*.

For the rockery, the stone crop, *Sedum pulchellum*, will be good, and the *Houstiana angustifolia*. This last has flowers of pinkish white, which remind one of the bouvardias.

In preparing the soil for your wild flowers, you will need to be careful not to make it too rich; since many wild flowers will be coarsened by too much plant-food. The violets, particularly, will give you no blossoms, but a great growth of leaves. All plants from the prairies will do well in ordinary garden soil. It is not necessary to try to imitate their native soil. The plants from the wood will need shade, and watering now and then. The north side of a hedge fence trimmed somewhat high would be best; but the shady side of a stone wall or building, perhaps the house itself, will do very well. Woodland plants will do better for an admixture of leaf loam in the soil; and it seems to be a necessity for ferns.

In making the water garden, it would be well, I think, to sink the half-barrel, or whatever you use, in the ground in a shady place; then, the most of your water-plants will grow about the edge, where you can keep them sufficiently moist.

It will not be necessary to know the scientific names of flowers, nor even any name at all. We have very few poisonous plants, and those are not usually attractive; so that you may take anything that strikes your fancy. It may be best to gather seeds of late-blooming sorts, sowing the seed in early spring, not too early for warmth.

My paper will not be complete perhaps, unless I add a few "do n'ts."

It would be best to avoid cultivating any member of the family *Convolvulus*, or morning-glory. You will be tempted, if you love vines, to take the *Ipomœa pandurata*, old-man-in the-ground, largely advertised a few years ago as the hardy day moonflower, but *do n't*. Nor must you have anything to do with the beautiful white bindweed, unless you have courage to pull up and dig out all sprouts you do not wish to grow. Nor would I advise growing any of the sunflowers, although our common sunflower, *Helianthus annuus*, is a bright and wholesome plant; yet it has, sometimes, such a quantity of seed that it is impossible to prevent its spreading. Another member of the family, our abundant rock-weed, *Helianthus orgyalis*, is grown in Eastern gardens and considered very desirable. The long, drooping leaves are as much in demand as the flower.

Of the ox-eyed daisy and the sweet clovers I need not speak. You all know their capabilities.

ADDITIONS TO THE LIST OF KANSAS COLEOPTERA FOR THE YEARS 1899 AND 1900.

BY WARREN KNAUS, MCPHERSON.

Read before the Academy December 28, 1900.

The additions to the list of Kansas coleoptera for the past two seasons number 236 species, a much larger number than has been added in recent years. This has largely been through the work of Mr. F. F. Crevecœur, of Onaga, Kan., who has, by careful collecting among the small forms near his home, added 150 species. Quite a number of those added the past two years were rare and unique forms, representing the northern extension of the Texan fauna.

The present additions bring the number of Kansas coleoptera up to 2500, and a careful revision of material now in Kansas collections would certainly increase this number to a considerable extent.

The bulk of the determinations in the present list were made by Mr. Charles Liebeck, of Philadelphia, Pa., in charge of the Dr. G. H. Horn collection of coleoptera; H. C. Fall, of Pasadena, Cal., and by the Department of Agricu Washington, D. C., to whom acknowledgments are due.

HENSHAW'S NUMBERS, WITH LATER DETERMINATIONS UNNUMBERED.

25*b*	Cicindela graminea Schaupp.....	Salina, Medora, McPherson, Mar., April, September, October.
59*a*	" apicalis W. Horn.....	Republic, Stafford, Kiowa, Salt Marsh, June, July, August.
240	Dyschirius erythrocerus Lec.....	Onaga.
456	Tachys xanthopus Dej.....	Salina.
462	" granarius Dej.....	Onaga.
482	Trechus rubens Fab.....	Onaga.
563	Pterostichus texanus Lec	Coolidge, June. One specimen.
603	" mandibularis Kirby.....	Onaga.
618	Evarthrus torvus Lec.....	Onaga.
766	Platynus sinuatus Dej.....	Onaga.
839	Olisthopus parmatus Say	Onaga.
924	Callida fulgida Dej	Onaga.
949	Apenes lucidula Dej	McPherson, July, August. Electric lights.
957	Helluomorpha clairvillei Dej	Medora, May 29. Two specimens.
1001	Chlænius diffinis Chd.....	Onaga.
1049	Oodes texanus Lec.....	Onaga.
1233	Haliplus edentulus Lec.....	McPherson. Electric lights. August.
1275	Bidessus affinis Say.....	Onaga.
1310	Hydroporus pulcher Lec.....	Wilson county.
1311	" vittatipennis Lec.....	Wilson county.
1496*b*	Thermonectes latecinctus Lec.....	Onaga.
1532	Dinuetes vittatus Germ.....	McPherson, June, July, August. Electric lights.
1594	Hydrophilus ellipticus Lec.....	Wallace, July.
1685	Phœnonotum extriatum Say	Near Marquette, October 15.
.....	Anisotoma, sp. near strigata Lec	Onaga.
1795	Agathidium exiguum Melsh.....	Onaga.
1831	Scydmænus hirtellus Lec	Onaga.
1877	Pselaphus erichsonii Lec.....	Onaga.
1996	Falagria cingulata Lec.....	Onaga.
.....	Hoplandria ochraceæ	Onaga.
.....	Aleochara, three new species.....	Onaga.
2186	Philonthus fulvipes Fab.....	Onaga.
2207	" inquietus Er	Onaga.
2274*a*	Xantholinus fusiceps Fauval.....	Onaga.
2443	Stenus flavicornis Er.....	Onaga.
2572	Pæderus palustris Aust	Onaga.
2591	Palaminus nomalus Lec.....	Onaga.
2625	Tachinus fumipennis Say.....	Onaga.
2666	Boletobius cinctus Grav	Onaga.
2670	Bryoporus rufescens Lec.....	Onaga.
2799	Geodromicus brunneus Say.....	Near Marquette, October 15.
2852	Homalium humorosum Fauv.....	Benedict.
2914	Nossidium americanum Mots.....	Onaga.
3024	Corylophus truncatus Lec.....	Onaga.
3043	Hippodamia lecontei Muls.....	Onaga.
3055	Coccinella affinis Rand.....	Onaga and Hutchinson, May.
3088	Cryptognatha pusilla Lec	Onaga.
3160	Scymnus punctum Lec.....	Onaga.

3168	Scymnus phelpsii Cr.	Near Superior, Neb., June.
.....	" intrusus Horn	Onaga.
.....	" n. sp.	Onaga.
3225*a*	Tritoma ruficeps Lec.	Onaga.
3225*c*	" aulica Horn	Onaga.
3339	Læmophlœus ferrugineus Steph	Onaga.
.....	Crosimus hirtus Casey	Onaga.
3364	Cryptophagus cellaris Scop	Onaga.
3387	Atomaria lætula Lec.	Onaga.
3503	Hister bimaculatus Linn	McPherson, May.
3640	Teretrius americanus Lec	Onaga.
3673	Carpophilus pallipennis Say, var floralis Er.	Belvidere, June.
3675	" melanopterus Er., and var. rufus, Murry.	Rago and Medora, in yucca flowers, May and June.
3706	Epurea avara Rand.	Benedict, April.
3805	Corticaria serrata Payk	Onaga.
3871	Bactridium striolatum Reit.	Onaga.
3919	Pelonomus obscurus Lec.	McPherson, elec. lights, June, July.
10015	Heterocerus gemmatus Horn	Onaga.
4006	Scirtes orbiculatus Fab.	Onaga.
4041	Fornax calceatus Say	Benedict.
4064	Analastes druryi Kirby.	McPherson, August.
4064*a*	" latreillei Lec.	McPherson. Electric lights.
4068	Sarpedon scabrosus Bonv.	Onaga.
.....	Cryptohypnus, n. sp.	Onaga.
4297	Dolopius lateralis Esch.	Onaga.
4358	Limonius plebejus Say	Onaga.
4363	" quercinus Say.	Onaga.
4476	Corymbites medianus Germ	Onaga.
10071	Chrysobothris purpureovittata Horn	Belvidere, June. Three specimens.
10091	" scitula Gory	Onaga.
4666	Actenodes acornis Say	Onaga.
4721	Agrilus ruficollis Fab.	Onaga and Salina.
10129	" abjectus Horn.	Onaga.
4740	" torpidus Lec.	Onaga.
4828	Photinus lineellus Lec.	Onaga.
4958	Telephorus lautus Lec.	Onaga.
4975	Malthinus occipitalis Lec.	Onaga.
4979	Malthodes concavus Lec.	Onaga.
.....	Pseudebæus, n. sp.	Onaga and Salina.
5051	Attalus basalis Lec	Onaga.
5099	Pristoscelis rufipennis Lec.	Wallace, July.
5120	Dasytes ruficollis Ulke.	Onaga.
5136	Cymatodera bicolor Say.	Onaga.
5159	Trichodes nuttalli Kirby.	Medora, June. One specimen.
5272	Hadrobregmus linearis Lec.	Onaga.
.....	Eupactus, n. sp	Onaga.
.....	Xyletinus, n. sp., near lugubrius, Lec.	Onaga.
.....	Hemiptychus, n. sp.	Onaga.
5321	Dorcatoma setulosum Lec.	Onaga.
5400	Cis punctatus Mellie.	Onaga.
5427	Canthon depressipennis Lec.	Coolidge, June,
5439	" perplexus Lec.	Benedict. One specimen.

10189	Atænius strigatus Say	Onaga.
10190	" cognatus Lec	Onaga.
5521	Aphodius haldemani Horn	Onaga.
5629	Trox scaber Linn	Onaga.
5718	Diplotaxis dubia Lec	Onaga.
.....	" n. sp	Rago, June.
5841	Strigoderma pygmæa Fab	Rago and Spivey, June.
6093	Obrium rubidum Lec	Benedict. One specimen.
6210	Cyrtophorus verrucosus Oliv	Onaga.
6213	Euderces pini Oliv	Onaga.
6259	Acmæops bivittata Say	Onaga.
6354	Leptura pubera Say	Onaga.
6435	Lepturges symmetricus Hald	Onaga.
6440	Hyperplatys aspersus Say	Onaga.
.....	Mecas cana Newm	Belvidere, June.
6496	Oberea bimaculata Oliv	Onaga.
6501	" ocellata Hald	Onaga.
6503*a*	" myops Hald	Medora, June.
6535	Donacia distincta Lec	Onaga.
6562	Lema cornata Fab	Medora, June.
6604	Exema gibber Oliv	Onaga.
6608	Bassareus formosus Melsh	Rago and Coolidge, June.
6610	" mammifer Newm	Onaga.
6610*c*	" luteipennis Melsh	Onaga.
6628*c*	Cryptocephalus cinctipennis Rand	Onaga.
6725	Fidia viticida Walsh	Onaga.
10359	Metachroma parallelum Horn	Medora, May, June, on willow.
6753	" angustata Cr	Medora, May, June, on willow.
6764	" lævicollis Cr	Onaga.
10363	Graphops varians Lec	Belvidere, June, July, August.
.....	Rhabdoptera, n. sp	Onaga.
6805	Chrysomela elegans Oliv	Onaga.
.....	Zygogramma heterothecæ Lin	Belvidere, June, July, August.
6856	Luperus thoracicus Melsh	Onaga.
6891*a*	Diabrotica fossata Lec	Onaga.
6892*a*	Trirhabda virgata Lec	Onaga.
6894	" attenuata Say	Wallace, July.
6901	Adimonia sexvittata Lec	Onaga.
6917	Monoxia consputa Lec	Coolidge, May.
6958*a*	Disonycha collata Fab	Onaga.
6972	Haltica punctipennis Lec	Wallace and Belvidere, June, July.
6990	Crepidodera lobata Cr	Onaga.
10431	Orthaltica melina Horn	Onaga.
7008	Longitarsus testaceus Lec	Onaga.
7029	Phyllotreta æneicollis Cr	Onaga.
7032	Mantura floridana Cr	Near Superior, Neb., May.
7067	Microrhopala excavata Oliv	Onaga.
7100	Cassida texana Cr	Belvidere, Aug. One specimen.
7136	Bruchus pauperculus Lec	Onaga.
7155	" musculus Say	Onaga.
7431	Blapstinus sulcatus Lec	Coolidge, June.
7476	Alphitobius piceus Oliv	McPherson, July.

7523	Platydema micans Horn	McPherson, June.
.....	Hymenorus, n. sp.	Belvidere, June.
7590	Allecula atra Say	Medora.
7607	Cistela sericea Say	Onaga.
.....	Mycetocharis n. s., near megalops Csy.	Onaga.
7773	Tomoxia bidentata Say	Wallace, July.
7799	Mordellistena lepidula Lec	Onaga.
7852	" bihamata Melsh	Onaga.
7899	Xylophilus basalis Lec	Onaga.
7900	" nebulosus Lec	Onaga.
.....	" two new species	Onaga.
.....	Lappus lividus Csy	Belvidere, August.
7930	Mecynotarsus candidus Lec	Medora, June. Sand-hills.
7939	Anthicus tenuis Lec	Onaga.
.....	" n. sp.	Onaga.
7976	" pallens Lec	Medora, June. Sand-hills.
.....	Malporus properus Csy	Onaga.
7994	Dendroides canadensis Lat	Onaga.
8050	Zonitis longicornis Horn	Onaga.
8139	Cantharis biguttata Lec	Wallace, July.
8140	" fulvipennis Lec	Belvidere, June, on Mex. poppy.
8183	Myodites scaber Lec	McPherson, June; and Onaga.
8209	Eugnamptus sulcifrons Gyll.	Onaga.
8216	Rhynchites glastinus Lec	Coolidge, June.
8228	Attelabus rhois Boh	Onaga.
8257	Dichoxenus setiger Horn	Rago and Garden City, June.
8307	Trachyphlœus, asperatus Boh.	Onaga.
.....	" n. s. near asperatus Boh.	McPherson.
8336	Mitostylus tenuis Lec	Belvidere, June, July, August.
8371	Apion impunctistriatum Sm.	Rago, June.
8397	" oblitum Sm.	Medora, Belvidere, Sharp's Creek, June.
8409	" modestum Sm.	Near Superior, Neb., Rago, May to August.
8414	" varicorne Sm.	Wallace, July.
8419	" tenuirostrum Sm	McPherson, June.
8466	Macrops humilis Gyll	McPherson. Electric lights.
10834	" obscurellus Deitz	Onaga.
8515	Cleonopsis pulvereus Lec	Belvidere, August.
8523	Cleonus canescens Lec.	Rago, June.
10896	Desmoris pervisus Deitz	Belvidere, August.
8563	Phyllotrox nubifer Lec.	Onaga.
8570	Endalus setosus Lec.	McPherson, Wallace, July.
.....	" n. sp.	Wallace, July.
.....	" n. sp., near cribricollis Lec.,	Onaga.
8578	Anchodemus angustus Lec.	McPherson, June.
10971	Macrorhoptus hispidus Deitz.	Near Superior, Neb., June. One specimen.
.....	Bagous, n. sp.	Onaga.
8615	Magdalis barbita Say	Benedict. One specimen.
8623	" inconspicua Horn	Onaga.
8653	Anthonomus tectus Lec.	Belvidere, August.
8654	" hirtus Lec.	Wallace and Coolidge, July.

8661	Anthonomus crategi Walsh	Onaga.
.....	" molaculus Csy	Rago, August.
10987	" bolteri Deitz	Onaga, and Superior, Neb.
10992	" consimilis Deitz	Onaga.
10999	" albophilosus Deitz	Belvidere and Phillips county, July, August.
8673	Orchestes pallicornis Say	Onaga.
11019	Pseudanthonomus incipiens Deitz	Salina.
8685	Piazorhinus scutellaris Say	Onaga.
8693	Tylopterus varius Lec	Onaga.
8718	Conotrachelus elegans Say	Onaga and McPherson.
8738	" erinaceus Lec	Onaga and southeast Kansas.
8812	Copturus nanulus Lec	Rago, June.
8834	Cœliodes flavicaudis Boh	Onaga.
8845	Ceutorhynchus pusio Mann	Onaga.
8852	" septentrionalis Gyll	Onaga.
.....	" affluentus Csy	Onaga.
8865	Rhynonchus longulus Lec	Onaga.
.....	" occidentalis	Onaga.
.....	Acanthocelis curtus	Onaga and Salina.
11144	Ampeloglypter longipennis Csy	Salina and Onaga.
11186	Limnobaris deplanata Csy	Onaga.
8900	Onychobaris rugicollis Lec	Onaga.
11210	Barilepton famelicum Csy	Onaga.
8960	Balaninus uniformis Lec	McPherson, June. Electric lights.
.....	" sulcatulus Csy	Onaga.
.....	Sphenophorus, n. sp	Coolidge, July.
9055	Monarthrum fasciatum Say	Benedict, April.
9111	Xyleborus pubescens Zimm	Onaga.
9152	Scolytus ventralis Lec	Onaga.
9228	Brachytarsus tomentosus Say	Onaga.
.....	" n. sp	Onaga.
9230	Anthribulus rotundatus Lec	McPherson, May. One specimen.

THE BLACK DUCK IN KANSAS.

BY R. MATTHEWS, WICHITA.

Read before the Academy, by Secretary Lantz, December 29, 1900.

I have left with Mr. B. B. Smyth, curator of the Academy, a skin of the black duck, *Anas obscura* (Gmel.)* It was captured at Greenfield lake, in the extreme southwestern part of Reno county, in 1896, by Mr. C. H. Smyth.

Another specimen, which I have sent to Professor Snow, was taken in November, 1891, at the same place and by the same person. They have been in my possession since their capture.

I wish to report the birds and send the skin in corroboration, as they have been in dispute since 1872, when Professor Snow reported them in his first catalogue of the birds of Kansas.

*I have examined the skin referred to, and find that, although not typical of the adult bird, it must unquestionably be referred to *Anas obscura* instead of *Anas fulvigula maculosa*. (Senn.), (the mottled duck), as have the specimens heretofore known to have been taken in the state.—D. E. LANTZ.

ANNOTATED CATALOGUE OF THE CRAYFISHES OF KANSAS.

(Abstract.)

BY J. ARTHUR HARRIS, UNIVERSITY OF KANSAS, LAWRENCE.

Read before the Academy December 29, 1900.

In 1885 Dr. Walter Faxon published* a "Preliminary Catalogue of the Crayfishes of Kansas." Since our knowledge of Kansas forms is more extensive now than when Doctor Faxon's catalogue appeared, as well as for the convenience of those wishing to study Kansas forms and their distribution, Faxon's publication being somewhat inaccessible, it has been deemed advisable to bring this catalogue up to date. In this abstract the citations of literature, museum numbers, collectors, etc., is omitted, only a list of the species and their distribution, with the briefest notes on their habits, being given.

In 1868, when Doctor Hagen's "Monograph of the North American Astacidæ" was finished, no crayfish were reported from Kansas. We now recognize nine species and one variety (?). Of these Doctor Faxon's catalogue reported seven species and one variety. Of the 105 counties in the state, we have reports on the cambarid fauna from only twenty-four.

The following is a list of the species, with their distribution by counties:

1. *Cambarus simulans* Faxon. Barber, Ellis.

2. *C. gracilis* Bundy. A burrowing species, spending most of its time in burrows, which it forms in meadows, etc., often at considerable distance from a body of water. They may be taken at the tops of their burrows at night, when they are doubtless watching for food, during the summer months. In early spring they are to be found in stagnant ponds, etc. Labette, Douglas.

3. *C. baumgartneri* Harris. Found in creeks and sloughs; burrows in fall. Harvey, Sumner.

4. *C. diogenes* Girard. A burrowing species, not often found in open ponds or streams, except in early spring. Douglas, Leavenworth.

5. *C. immunis* Hagen. Very abundant in shallow, stagnant ponds, going into burrows upon the approach of winter or drying up of the water. Ellis, Douglas, Leavenworth.

5*b*. *C. immunis* Hagen, var. *spinostris* Faxon. Shawnee, Douglas.

6. *C. nais* Faxon. Labette, Montgomery.

7. *C. virilis* Hagen. This appears to be the most widely distributed species in our state, being reported from fifteen different counties: Cherokee (?), Decatur, Dickinson, Douglas, Ellis, Finney, Geary (?), Jefferson, Kiowa, Leavenworth, Linn, Riley, Shawnee, Sumner, Wabaunsee.

8. *C. neglectus* Faxon. Wabaunsee, Cheyenne.

9. *C. pelosus* Hay. Mitchell, Russell.

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*Bulletin Washburn College Lab. Nat. Hist., vol. I, p. 140. 1885.

A LIST OF BIRDS SEEN IN DICKINSON COUNTY, KANSAS, FROM AUGUST, 1898, TO AUGUST, 1900.

BY D. E. LANTZ, MANHATTAN.

Read before the Academy December 28, 1900.

During my two years' residence in Dickinson county my opportunities for field observations were limited, and they were consequently casual and far from systematic. They were confined principally to the eastern part of the county, in the vicinity of Chapman. This place has an elevation of 1053 feet above sea-level and is in the flood plain of the Smoky Hill river. The native timber is confined to a fringe on the banks of the river itself and along the streams which flow into it. Orchards and plantations are numerous.

The limestone formation of the hills bordering the river valley shows a tendency here and there to give way to the sandstone of the Solomon valley. At intervals there are sand-hills partly covered by a dense growth of the sand-plum, *Prunus watsoni* (Sarg.)

The avifauna of this part of the county shows no striking changes from that found at Manhattan. The birds are decidedly those of the eastern part of the state, with fewer of the woodland species. The Arkansas Kingbird, *Tyrannus verticalis* (Say), of which a single pair were seen, was the only bird observed of which I have no Manhattan record. The list which follows is far from a complete one, and is offered only as a contribution toward a better knowledge of the distribution of our Kansas birds in the state. One hundred and thirty-three species are recorded, of which seventy-six are summer resident and probably breed in the county.

1. 4. Colymbus nigricollis californicus (Heerm.) American Eared Grebe. A specimen seen in the hands of a boy, who had shot it on a pond.

2. 6. Podilymbus podiceps (Linn.) Pied-billed Grebe. Probably breeds; a few seen.

3. 54. Larus delawarensis (Ord.) Ring-billed Gull. Migratory; seen along the Smoky Hill river.

4. 69. Sterna forsteri (Nutt.) Forster's Tern. Migratory; seen flying along the river.

5. 77. Hydrochelidon nigra surinamensis (Gmel.) Black Tern. Migratory.

6. 125. Pelecanus erythrorhynchus (Gmel.) American White Pelican. Migratory; common.

7. 132. Anas boschas (Linn.) Mallard. Seen in migration only.

8. 137. Mareca americana (Gmel.) Baldpate. Seen on Chapman creek.

9. 139. Nettion carolinensis (Gmel.) Green-winged Teal. A common migrant.

10. 140. Querquedula discors (Linn.) Blue-winged Teal. A common migrant.

11. 143. Dafila acuta (Linn.) Pintail. Migratory; one of the few species that can be distinguished when flying, although distant from the observer.

12. 146. Aythya americana (Eyt.) Red-head. Migratory.

13. 150. Aythya collaris (Donov.) Ring-necked Duck. Migratory; seen in the possession of hunters.

14. 169. Chen hyperborea (Pall.) Lesser Snow Goose. Seen in migration.

15. 172. Branta canadensis (Linn.) Canada Goose. Winter sojourner and migrant. This bird finds abundant winter food on the extensive wheat-fields of the county.

16. 194. Ardea herodias (Linn.) Great Blue Heron. Summer resident; seen several times; nests on Chapman creek.

17. 201. Ardea virescens (Linn.) Green Heron. Summer resident; rather common.

18. 204. Grus americana (Linn.) Whooping Crane. Migratory; seen flying.

19. 206. Grus mexicana (Müll.) Sandhill Crane. Migratory; seen several times in flocks, flying.

20. 214. Porzona carolina (Linn.) Sora. Migratory; not common, because marshes are scarce.

21. 221. Fulica americana (Gmel.) American Coot. Seen only in migration, but probably breeds in the county.

22. 225. Recurvirostra americana (Gmel.) American Avocet. Reported from the county, but not seen. Migratory.

23. 239. Tringa maculata (Vieill.) Pectoral Sandpiper. Migratory. Only once seen, but is probably common in suitable places.

24. 240. Tringa fuscicollis (Vieill.) White-rumped Sandpiper. Migratory; a few seen.

25. 241. Tringa bairdii (Coues). Baird's Sandpiper. Migratory.

26. 242. Tringa minutilla (Vieill.) Least Sandpiper. Migratory; fairly common.

27. 254. Totanus melanoleucus (Gmel.) Greater Yellow-legs. Migratory; seen but once.

28. 255. Totanus flavipes (Gmel.) Yellow-legs. Migratory; a few seen.

29. 261. Bartramia longicauda (Bechst.) Bartramian Sandpiper. Summer resident; common.

30. 263. Actitis macularia (Linn.) Spotted sandpiper. Summer resident; fairly common.

31. 272. Charadrius dominicus (Müll.) American Golden Plover. Migratory; a single specimen seen.

32. 273. Ægialitis vocifera (Linn.) Killdeer. A summer resident; common.

33. 289. Colinus virginianus (Linn.) Bob-white. Resident; common.

34. 305. Tympanuchus americanus (Reich.) Prairie Hen. Resident; formerly abundant, but now becoming quite scarce.

35. 316. Zenaidura macroura (Linn.) Mourning Dove. Summer resident; abundant; often seen in sheltered places in winter.

36. 325. Cathartes aura (Linn.) Turkey Vulture. Summer resident; common.

37. 331. Circus hudsonius (Linn.) Marsh Hawk. A common resident. One of our most useful birds, against which nearly every gun is turned in eve

38. 332. Accipiter velox (Wils.) Sharp-shinned Hawk. Seen several times in migration.

39. 333. Accipiter cooperi (Bonap.) Cooper's Hawk. A resident species; not very common.

40. 337. Buteo borealis (Gmel.) Red-tailed Hawk. Resident; fairly common.

41. 342. Buteo swainsoni (Bonap.) Swainson's Hawk. Not common, but may breed; seen only in fall.

42. 347a. Archibuteo lagopus sanctijohannus (Gmel.) American Rough-legged Hawk. Winter sojourner; a few seen.

43. 349. Aquila chrysaëtus (Linn.) Golden Eagle. Winter sojourner. Several were captured near Chapman and offered to me for mounting.

44. 352. Haliaëtus leucocephalus (Linn.) Bald Eagle. Seen in spring; rare.

45. 360. Falco sparverius (Linn.) American Sparrow Hawk. Resident; frequently seen.

46. 365. Strix pratincola (Bonap.) American Barn Owl. Resident; not uncommon.

47. 373. Megascops asio (Linn.) Screech Owl. Common; resident. Only the gray form seen.

48. 375. Bubo virginianus (Gmel.) Great Horned Owl. Resident; common.

49. 378. Speotyto cunicularia hypogæa (Bonap.) Burrowing Owl. Summer resident. Observed by the writer in Dickinson county in 1881.

50. 387. Coccyzus americanus (Linn.) Yellow-billed Cuckoo. Summer resident; common.

51. 390. Ceryle alcyon (Linn.) Belted Kingfisher. Resident; not rare.

52. 393. Dryobates villosus (Linn.) Hairy Woodpecker. Resident; not common.

53. 394c. Dryobates pubescens medianus (Swains.) Downy Woodpecker. Resident; common.

54. 406. Melanerpes erythrocephalus (Linn.) Red-headed Woodpecker. Summer resident; common.

55. 409. Melanerpes carolinus (Linn.) Red-bellied Woodpecker. Resident; a few seen.

56. 412. Colaptes auratus luteus (Bangs). Flicker. Resident; common.

57. 413. Colaptes cafer (Gmel.) Red-shafted Flicker. A winter sojourner; common.

58. 418. Phalænoptilus nuttalli (Aud.) Poor-will. A common summer resident. Among all of the birds seen, I found none of the frosted form, *nitidus* (Brewst.)

59. 420. Chordeiles virgianianus (Gmel.) Night Hawk. Summer resident; common. No specimens of the western form, *C.* v. *henryi* (Cass.), were observed.

60. 423. Chætura pelagica (Linn.) Chimney Swift. Summer resident; abundant.

61. 428. Trochilus colubris (Linn.) Ruby-throated Humming-bird. Seen only in migration.

62. 444. Tyrannus tyrannus (Linn.) Kingbird. Summer resident; abundant.

63. 447. Tyrannus verticalis (Say). Arkansas Kingbird. A pair seen May 5, 1899.

64. 452. Myiarchus crinitus (Linn.) Crested Flycatcher. Summer resident; common.

65. 456. Sayornis phœbe (Lath.) Phœbe. A summer resident; common.

66. 461. Contopus virens (Linn.) Wood Pewee. Summer resident; fairly common.

67. 474a. Otocoris alpestris leucolæma (Coues). Pallid Horned Lark. Common in midwinter.

68. 474b. Otocoris alpestris praticola (Hensh.) Prairie Horned Lark. Resident; abundant.

69. 477. Cyanocitta cristata (Linn.) Blue Jay. Resident; common.

70. 488. Corvus americanus (Aud.) American Crow. Resident; abundant.

71. 495. Molothrus ater (Bodd.) Cowbird. Summer resident; abundant.

72. 497. Xanthocephalus xanthocephalus (Bonap.) Yellow-headed Blackbird. Seen only in migration.

73. 498. Agelaius phœniceus (Linn.) Red-winged Blackbird. Summer resident; common.

74. 501b. Sturnella magna neglecta (Aud.) Western Meadow-lark. Summer resident; abundant.

75. 506. Icterus spurius (Linn.) Orchard Oriole. Summer resident; abundant.

76. 507. Icterus galbula (Linn.) Baltimore Oriole. Summer resident; abundant.

77. 510. Scolecophagus cyanocephalus (Wagl.) Brewer's Blackbird. Migratory; common.

78. 511b. Quiscalus quiscala æneus (Ridgw.) Bronze Grackle. Summer resident; abundant.

79. 521a. Loxia curvirostra stricklandi (Ridgw.) Mexican Crossbill. Winter sojourner. Several flocks seen.

80. 529. Astragalinus tristis (Linn.) American Goldfinch. Resident; common.

81. 533. Spinus pinus (Wils.) Pine Siskin. Winter sojourner; common.

82. 536. Calcarius lapponicus (Linn.) Lapland Longspur. A winter sojourner; common.

83. 542a. Ammodramus sandwichensis savanna (Wils.) Savanna Sparrow. A common migrant.

84. 546. Ammodramus savannarum passerinus (Wils.) Grasshopper Sparrow. Summer resident; common.

85. 552. Chondestes grammacus (Say). Lark Sparrow. Summer resident; abundant.

86. 553. Zonotrichia querula (Nutt.) Harris's Sparrow. An abundant winter sojourner.

87. 554. Zonotrichia leucophrys (Forst.) White-crowned Sparrow. Seen once in migration.

88. 554a. Zonotrichia leucophrys intermedia (Ridgw.) Intermediate Sparrow. Migratory; common.

89. 559. Spizella monticola (Gmel.) Tree Sparrow. An abundant winter sojourner.

90. 560. Spizella socialis (Wils.) Chipping Sparrow. Summer resident; not common.

91. 561. Spizella pallida (Swains.) Clay-colored Sparrow. Migratory; abundant.

92. 563. Spizella pusilla (Wils.) Field Sparrow. Summer resident; heard several times.

93. 567. Junco hyemalis (Linn.) Slate-colored Junco. Winter sojourner. rather common.

94. 567a. Junco hyemalis oregonus (Towns.) Oregon Junco. Winter sojourner; common.

95. 581. Melospiza fasciata (Gmel.) Song Sparrow. Winter sojourner; common.

96. 583. Melospiza lincolni (Aud.) Lincoln's Sparrow. Migratory; common.

97. 585. Passerella iliaca (Merr.) Fox Sparrow. Seen in early spring; not common.

98. 587. Pipilo erythrophthalmus (Linn.) Towhee. Summer resident; common.

99. 588. Pipilo maculatus arcticus (Swains.) Arctic Towhee. Migratory; common.

100. 593. Cardinalis cardinalis (Linn.) Cardinal. Resident; abundant.

101. 597. Guiraca cærulea (Linn.) Blue Grosbeak. Summer resident; common.

102. 598. Cyanospiza cyanea (Linn.) Indigo Bunting. Summer resident; common.

103. 604. Spiza americana (Gmel.) Dickcissel. Summer resident; abundant.

104. 610. Piranga erythromelas (Vieill.) Scarlet Tanager. Summer resident; common.

105. 611. Progne subis (Linn.) Purple Martin. Summer resident; common.

106. 613. Hirundo erythrogaster (Bodd.) Barn Swallow. Summer resident; common.

107. 616. Clivicola riparia (Linn.) Bank Swallow. Summer resident; common.

108. 617. Stelgidopteryx serripennis (Aud.) Rough-winged Swallow. Summer resident; not common.

109. 619. Ampelis cedrorum (Vieill.) Cedar Waxwing. Migratory; common.

110. 621. Lanius borealis (Vieill.) Northern Shrike. Winter sojourner; common.

111. 622a. Lanius ludovicianus excubitorides (Swains.) White-rumped Shrike. Summer resident; common.

112. 624. Vireo olivaceus (Linn.) Red-eyed Vireo. Summer resident. A few heard.

113. 627. Vireo gilvus (Vieill.) Warbling Vireo. Summer resident; common.

114. 633. Vireo bellii (Aud.) Bell's Vireo. Summer resident; common.

115. 652. Dendroica æstiva (Gmel.) Yellow Warbler. Summer resident; common.

116. 655. Dendroica coronata (Linn.) Myrtle Warbler. Migratory; not very common.

117. 676. Seiurus motacilla (Vieill.) Louisiana Water-thrush. Summer resident; not common.

118. 681a. Geothlypis trichas occidentalis (Brewst.) Western Yellow-throat. Summer resident; rare.

119. 683. Icteria virens (Linn.) Yellow-breasted Chat. Summer resident; common.

120. 703. Mimus polyglottos (Linn.) Mocking-bird. Summer resident; common.

121. 704. Galeoscoptes carolinensis (Linn.) Catbird. Summer resident; common.

122. 705. Harporhynchus rufus (Linn.) Brown Thrasher. Summer resident; abundant.

123. 719b. Thryomanes bewickii leucogaster (Salv. and Godw.) Baird's Wren. Summer resident; several heard.

124. 721b. Troglodytes aëdon aztecus (Baird). Western House Wren. Summer resident; common.

125. 726. Certhia familiaris fusca (Barton). Brown Creeper. Winter sojourner; only a few seen.

126. 727. Sitta carolinensis (Lath.) White-breasted Nuthatch. Resident; common.

127. 731. Parus bicolor (Linn.) Tufted Titmouse. Resident; not common.

128. 735. Parus atricapillus (Linn.) Chickadee. Resident; common.

129. 735a. Parus atricapillus septentrionalis (Harris). Long-tailed Chickadee. Resident; more common than the preceding form.

130. 749. Regulus calendula (Linn.) Ruby-crowned Kinglet. Migratory; not rare.

131. 755. Hylocichla mustelina (Gmel.) Wood Thrush. Summer resident; abundant.

132. 761. Merula migratoria (Linn.) American Robin. Resident; common.

133. 766. Sialia sialis (Linn.) Bluebird. Resident; not very comm

IV. GEOLOGY AND PALEONTOLOGY.

THE DAKOTA CRETACEOUS OF KANSAS AND NEBRASKA.

BY C. N. GOULD, UNIVERSITY OF OKLAHOMA, NORMAN, OKLA.

Read (by title) before the Academy December 28, 1900.

[A thesis submitted for the degree of Master of Arts May 7, 1900, by Charles Newton Gould, fellow in geology in the University of Nebraska, and accepted by the faculty June 4, 1900.]

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INTRODUCTION.

Few geological groups are so widely and yet so superficially known as the Dakota Cretaceous. From the time Lewis and Clarke, in 1804, first noticed the hills of soft, yellow sandstone along the Missouri river at Blackbird hill and Maha (Omaha) creek until the present, there have been papers and references galore to this formation. One of several reasons for this fact may be that it is the only distinctively sandstone group of the plains. All other formations—Paleozoic, Mesozoic, or Cenozoic—consist, chiefly, of limestones, shales, and silt. There are, or course, many ledges of sandstone in the Carboniferous and other groups, but with a few minor exceptions the statement is true.

The group is known, however, chiefly by its fossils. Perhaps no other formation has yielded so large and varied a collection of species. The fossils are, for the most part, plants, particularly dicotyledonous leaves, although both vertebrates and invertebrates are represented. Some of the most famous paleontologists, both phyto and invertebrate, of Europe and America have written concerning this group. The literature is scattered throughout government and state reports, proceedings of scientific societies, bulletins of numerous surveys, and various scientific periodicals, not to mention the polite literature of such authors as Irving and Cooper.

The present paper was undertaken with the intention of presenting a fairly complete description of the Dakota group in the light of the present knowledge of the subject. It was also planned to include descriptions and plates of a num-

ber of new species of plants collected during the field seasons of 1898 and 1899, by Dr. Lester F. Ward and the writer. Before the studies of the leaves were completed, however, Doctor Ward suggested that a monograph of the Dakota group be prepared with such geological discussions as recent investigations demanded, paying particular attention to the new species of plants. After consultation with Dr. Erwin H. Barbour, under whose direction the work was being done, it was decided that while such a work was feasible it was manifestly impossible to complete the entire subject in the limited time allowed. This necessitated a change in the plan of the work. The present paper, therefore, should be considered preliminary in character. The writer is not unmindful that the discussions are in places more in the character of a popular report than of a technical presentation of scientific data. This fact, however, may not necessarily be regarded as an unmixed evil. The work on the monograph along the lines suggested by Doctor Ward is in progress. The writer hopes within a reasonable time to present to the scientific world this contribution to the knowledge of one of our most interesting of geological groups.

In the work of the investigation of the various problems connected with the Dakota, I have had the kindly assistance and suggestion of Dr. Lester F. Ward and Dr. T. W. Stanton, of the United States Geological Survey. In the preparation of this article, I have been especially fortunate in the aid and criticism of Dr. Erwin H. Barbour and Mr. C. A. Fisher, of the University of Nebraska. To each of these gentlemen are due my heartfelt thanks.

HISTORICAL SKETCH.

No attempt has been made to prepare an exhaustive treatment on the history of the Dakota group. The literature is not only considerable but it is also widely scattered. Of the hundreds of articles and references dealing with this group, but a few of the most important will be cited. The subject naturally divides itself into four general heads, which have been somewhat loosely followed in the discussion. The first period, or that of early discovery, begins in 1804, and ends in 1856. The second extends from 1856, when Meek and Hayden began their famous controversy concerning the age of the beds, to 1864, the date of the publication of Mr. Marcou's paper in which he admits the Cretaceous age of the formation. The third period, during which Dr. Leo Lesquereux figured so prominently, began in 1866, and closed with the publication of "The Flora of the Dakota Group" in 1892, after the death of Doctor Lesquereux. The last period deals with the question of invertebrates and recent investigations.

For a more detailed account of the subject the reader is referred to the articles cited in the bibliography at the close of this paper. This bibliography, however, makes no pretentions to completeness.

EARLY DISCOVERIES.

It is to the records of the exploring expedition of Lewis and Clarke, which in 1804 ascended the Missouri river, that we must go for the first mention of the sandstone now known as the Dakota group. Previous to this time French and English traders and trappers had gone up the river, and had even built temporary trading stations along its banks; but these men, interested in pecuniary gain alone, left no record of the natural scenery of the country. The first account of the Lewis and Clarke expedition was published by Patrick Gass, a member of the party, in 1807. Under the date of August 10, 1804, Sergeant Gass says: "We stopped to examine some high yellow banks on the south side and camped on the north side."[1]

1. Jour. of Voyages, etc., of Lewis and Clarke, by Patrick Gass, pp. 27-28, 1807.

On the 11th, he speaks of some bluffs of yellow sand that extended for several miles along the river. A more comprehensive account is given in the journal kept by Captain Clarke, as follows: "We halted on the south side for the purpose of examining a spot where one of the great chiefs of the Mahas [Omahas], named Blackbird, was buried. A hill of yellow, soft sandstone rises from the river in bluffs of various heights till it ends in a knoll about 300 feet above the water."[2]

This was on August 11. The next day the following entry appears, referring to some hills a few miles further up the river: "Four miles beyond this bend a bluff begins and continues for several miles on the south; it rises from 20 to 150 feet, and consists of yellow and brown clay, with soft sandstone embedded in it."[3]

These three localities are easily recognized to-day. The high banks, first mentioned by Sergeant Gass, are the "High Banks," a mile north of Decatur, Neb. It is a curious coincidence, if nothing more, that the name casually used by Sergeant Gass is the one by which the bluff is now known throughout the region. Blackbird hill is still pointed out to the traveler through the Omaha reservation, and the person who will take the trouble to go up the river a mile above the old mission building will find the "bluff of yellow and brown clay with soft sandstone embedded in it."

The noted geographer, Nicollet, in his journey up the Missouri in 1839, mentions a number of formations, but seems to have confused the Dakota with the underlying Carboniferous. Audubon and Harris, in 1843, Evans, in 1849, and Culbertson, in 1850, were either not interested in geology, or else passed the sandstones of this group with a cursory examination, and devoted their time to the somewhat better-developed beds of the more recent formations further west.[4]

It was in 1853 that the first systematic work was done on the Cretaceous of the Missouri river, of which the Dakota forms the basal member. Dr. F. B. Meek and Dr. F. V. Hayden, men whose names are inseparably connected with the geology of the Northwest, were sent on an expedition to the Bad Lands by Dr. James Hall, of Albany. Although the time was spent chiefly among the later Cretaceous and Tertiary formations, a comprehensive idea of the whole series was obtained. It was during this trip that the first fossil leaves were found in the Dakota.

About this time Prof. Jules Marcou, a French geologist, published a geological map of the United States, in which he colored most of the region west of the Missouri river as Jurassic.[5]

On March 11, 1856, Meek and Hayden read a paper before the Philadelphia Academy of Science, entitled "Descriptions of New Species of Gastropods from the Cretaceous Formations of Nebraska Territory." In a prefatory note they discuss briefly the relations of the formations, and give the following section:

Tertiary	400–600 feet.
Cretaceous:	
No. 5. Gray and yellow arenaceous clays, containing great numbers of marine mollusks with a few land plants	100–150 "
No. 4. Plastic clay with numerous marine mollusks	350 "
No. 3. Gray and yellow calcareous marl containing *Ostrea congesta*, fish scales, etc	100–150 "
No. 2. Grayish and lead-colored clays having a few fossils	80 "
No. 1. Sandstone and clays not positively known to belong to the Cretaceous age	90 "
Upper Coal Measures, limestone at Council Bluffs.[6]	

2. Lewis and Clarke's Exp. up Mo. Riv., 1814, 1: 43. 3. Ibid.
4. Meek and Hayden, Proc. Phila. Acad. Sci., 8: 111, 112.
5. Bull. Geol. Soc. of France, 1850. 6. Proc. Phila. Acad. Sci., 8: 63-69.

This is the first draft of the now famous Missouri river section of the Cretaceous. With the publication of this section closes the first period in the history of the Dakota group.

THE MEEK-HAYDEN CONTROVERSY.

About three months after the reading of the article last referred to, Meek and Hayden read another paper, in which they discussed the various members of the Cretaceous, and especially No. 1. The statement is made that Professor Marcou is certainly mistaken in supposing that all the country west of the Missouri river was Jurassic, although they admit that their No. 1 may belong to that age.[7]

During the summer of 1856 these gentlemen again visited the region, and in November of that year published a paper in which the section given above is greatly elaborated. No. 1 is described as follows: "Heavy-bedded, yellowish sandstone, passing downward into alternations of sandstone and clay, containing bits of water-worn lignite and bands of dark carbonaceous matter. This formation is not positively known to belong to the Cretaceous system."

And the locality: "Near the mouth of the Big Sioux river and between there and Council Bluffs."

In the discussion of the various groups, referring to No. 1, they say: "We think it barely possible that these beds may be older than the Cretaceous. . . . If not older than the Cretaceous, we think they probably represent some of the older members of that system."[8]

On May 12, 1857, Doctor Hayden presented to the Philadelphia academy an article entitled "Notes Explanatory of a Map and Section illustrating the Geological Structure of the Country bordering on the Missouri River."[9] On May 26, Meek and Hayden read an article containing descriptions of fossils, and remarks on the Cretaceous and Tertiary formations of the Northwest.[10] These papers are quite exhaustive in the discussions of the various formations. The latter paper is especially interesting because of the fact that in it a number of comparisons are drawn with the Cretaceous of other portions of the United States. Sections are given from New Jersey, Alabama, Kansas, New Mexico; and the following conclusions reached regarding the basal member:

"There is at the base of the Cretaceous system, at distinctly separated localities in Nebraska, Kansas, Arkansas, New Mexico, Alabama, Texas, and New Jersey, a series of variously colored clays and sandstones of great thickness, in which organic remains, excepting leaves of trees, apparently dicotyledons, fossil wood and obscure casts of shells, are rarely found, but which everywhere presents a uniformity of lithological and other characters pointing to a similarity of physical conditions during their deposition over immense areas. Although the weight of evidence thus far favors the conclusion that this lower series is of the same age of the Lower Greensand or Necomian of the old world, yet we await positive evidence that portions of it may not be older than any part of the Cretaceous system."

By March, 1858, they had advanced yet another step, and, after reviewing the evidence of the dicotyledons in the rocks and the position of the adjacent strata, they say: "We think we hazard little in viewing at least a considerable portion of No. 1 as belonging to the Cretaceous system."

In the meantime Maj. F. Hawn had published a paper in which he referred to the whole of the sandstone formation in Kansas as Trias.[11] Doctor Hayden, in a paper before the Philadelphia academy, read July 29, 1858, took exceptions to the conclusions of Major Hawn; and, for apparently the first time, placed the

7. Loc. cit., 8: 111.
8. Proc. Phila. Acad. Sci., 8: 267.
9. Loc cit., 9: 109-116.
10. Loc. cit., 9: 117-133.
in Kansas, St. Louis Acad. Sci., 1: 171.

formation definitely in the Cretaceous. The following is Doctor Hayden's statement:

"The discovery at Blackbird hill during the past year of dicotyledonous leaves allied to the oaks, willows, and others of our deciduous forest-trees, together with their position with regard to other well-known Cretaceous formations, renders the evidence quite clear that a large portion of the strata which we had included in No. 1 of our vertical section is of Lower Cretaceous age. . . . Major Hawn has found the same or similar leaves in the formation in Kansas. . . . We have, therefore, arrived at the conclusion that No. 1, as it is revealed from Council Bluffs to the Big Sioux, is Lower Cretaceous, although two or three beds of yellow or ash-colored clays exposed at low-water mark near Blackbird hill may be Upper Jurassic."[12]

It is interesting to note the extreme slowness with which these distinguished scientists reached their conclusions regarding the age of this formation. Their opinion once formed, however, they never afterward changed it, and the geological world gradually came to accept their position. It was about this time that Meek and Hayden, desiring some paleobotanical evidence on the age of the beds, sent to Prof. Oswald Heer, the distinguished phytopaleontologist of Zurich, some outline sketches of a few of the plants. Not having heard from him for some months, the entire collection of fossil leaves was submitted to Dr. J. S. Newberry, who, after studying the forms, referred them to thirteen genera, and unhesitatingly placed them in the Cretaceous. This was in November, 1858.[13]

The same year Prof. G. C. Swallow published a paper entitled "Rocks of Kansas."[14] The sections given were made along the Kansas and Smoky Hill rivers, apparently as far west as Ellsworth county. The rocks of the state were divided into five groups, viz.: Quaternary, Cretaceous, Triassic, Permian, and Carboniferous. The Cretaceous rocks included the limestones and shales which are now known as the Fort Benton, and the 420 feet of sandstone and shale between these rocks and the Permian were designated as Triassic (?), although, in a foot-note, the statement is made that the name is only provisional and did not refer to the known age of the rocks.

The Dakota group, or rather the formation which has since received that name, was at this time (1858) considered as Triassic by Swallow and Hawn; as Jurassic by Marcou; and as Cretacous by Meek, Hayden, and Newberry. To add to the complication of the problem, Meek and Hayden received, on December 15 of this year, a letter from Professor Heer, in which he referred the plants, of which sketches had been sent him, to six genera, and inclined to the opinion that they were of Tertiary age.[15]

At the same time Professor Marcou published a paper addressed to "Messrs. F. B. Meek and F. V. Hayden," in which he quotes the conclusions of Professor Heer, and expresses the opinion that No. 1 of the Nebraska section is both Miocene and Jurassic.[16] In other words, he thinks that there are included in this group strata belonging to these two widely separated geological epochs. In their paper read December 21, Meek and Hayden express a high regard for the opinions of Professor Heer, but state that it is impossible for the formation to be Tertiary. They attribute his mistake to the fact that he saw only imperfect sketches of the leaves.[17] Concerning the matter, Doctor Lesquereux afterward said: "From what we know of the character of the Dakota leaves, it is clear that, judging from mere sketches, the celebrated professor of Switzerland could scarcely have come to a different conclusion."[18]

12. Proc. Phila. Acad. Sci., 9: 139-157.
13. Proc. Phila. Acad. Sci., 1858, p. 257.
14. St. Louis Acad. Sci., 1: 173-175.
15. Proc. Phila. Acad. Sci., 1858, pp. 265, 266.
16. J. Marcou, Zurich, 1858, 16 pp.
17. Loc. cit., pp. 257, 258.
18. Cretaceous Flora, U. S. Geol. Surv. of Terr., 6: 4.

The papers of Major Hawn and Professor Swallow induced Meek and Hayden to visit Kansas. In the summer of 1858 they ascended the Kansas and Smoky Hill rivers as far as the Smoky Hill buttes. As the result of this trip two articles were published, both in January, 1859. The first was entitled, "On the So-called Triassic Rocks of Kansas."[19] The second, "Geological Explorations in Kansas Territory."[20] In the first article, which is rather preliminary in character, the authors discuss the position assumed by themselves and by Major Hawn, and cite the authority of Doctor Newberry with regard to the dicotyledonous leaves to prove the Cretaceous age of the rocks. They admit, however, that the ledge which caps the Smoky Hill buttes may be either Triassic or Jurassic, but they also state that, in the absence of paleontological data, conjectures on this point are futile. One point mentioned in this paper may explain in a measure the confusion into which the discussion had fallen at this time. It is contained in the following lines: "There is no unconformity, as far as our knowledge extends, amongst all the rocks of Nebraska and northeastern Kansas, from the Coal Measures to the top of the most recent Cretaceous."

Had the obvious unconformity between the Permian and the Cretaceous, which has since been observed in numerous localities, been known to these pioneers in western geology, much of this misunderstanding would have been avoided. These men, not knowing that such unconformity existed, were simply trying to read into the geology of the region whole epochs which did not exist, in order to make the sequence correspond to that of European geology.

The second article referred to above deals at length with the formation under discussion. A number of sections are given, the last of which is entitled: "General Section of the Rocks of the Kansas Valley, from the Cretaceous down so as to Include Portions of the Upper Coal Measures." The upper member of this section, taken at the Smoky Hill buttes, is described as follows:

Red, brown, and yellowish, rather coarse-grained sandstone, often obliquely laminated, and containing many ferruginous concretions; also, fossil wood and many leaves of dicotyledonous trees, some of which belong to existing genera and others to genera peculiar to the Cretaceous epoch..... 60 feet.

This ledge is one of the most pronounced in the Dakota area. It forms the cap of the Smoky Hill buttes and of Soldier Cap mound, and may be traced for miles along the valley of the Smoky Hill river and its tributaries. The section of Meek and Hayden is not carried so high as that of Swallow, the latter including the Benton limestone, which is exposed about ten miles northwest of this locality. Below this ledge the authors describe 230 feet of sandstones and variously colored clays and shales before reaching the limestones and clays which they rightly consider the upper member of the Permian. Concerning these beds they say: "Between No. 5 (the Upper Permian) and the Cretaceous above (referring to the ledge at the buttes) there is still a rather extensive series of beds in which we found no fossils; they may be Jurassic or Triassic, or both; though, as we have elsewhere suggested, we rather incline to the opinion that they belong to the former age."

From the above it will be seen that Meek and Hayden at this time hesitatingly conceded the possibility of Jurassic beds in Kansas and Nebraska. The Kansas formations have since been demonstrated to belong to the Comanche Cretaceous, and, without further discussion, the beds at Blackbird hill have long been tacitly admitted to be Dakota.

It was at this time that the Heer-Newberry-Lesquereux controversy concern-

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19. Amer. Jour. Sci., 27: 31-35. 20. Proc. Phila. Acad. Sci., 11: 8-30.

ing the paleobotanical evidence of the age of the Dakota began. It will be remembered that Meek and Hayden had sent drawings of some of the leaves from this group to Professor Heer, who expressed an opinion that they belonged to the Tertiary. Doctor Newberry, however, to whom the leaves themselves had been submitted, considered them Cretaceous. In a letter to Prof. J. D. Dana, published in the *American Journal of Science*, Doctor Lesquereux quotes from Professor Heer, among other things, the following sentences:

"Your views of the flora of North America agree perfectly with what we find in Europe. This leads me to believe that the plants of Nebraska belong to the Tertiary and not to the Cretaceous formation. It is true that I have seen only some drawings which were sent to me by Messrs. Hayden and Meek, but they are all Tertiary types. The supposed *Crednaria* is very like *Populus luce* Ung. of the Lower Miocene; and the *Ettinghausiana* seems hardly rightly determined. Besides, it is a genus badly founded, and has as yet no value. All the other plants mentioned by Doctor Newberry belong to genera that are represented in the Tertiary and not in the Cretaceous. It is very improbable that in America the Cretaceous flora has had the characteristic plants of the Tertiary, and this would be the case if these plants did belong to the Cretaceous."[21]

Doctor Newberry took exception to these statements, and replied at length in a letter dated October 15, 1859, likewise published in the *American Journal of Science*.[22] He answered the objections of the Swiss professor in detail, and made the statement, which has since been universally accepted, that the vegetation in Cretaceous times had the same general aspect as that of the present.

Professor Lesquereux replied to this letter with another, in which he defended Professor Heer's statements, and discussed at some length the position of both parties.[23] Doctor Newberry again replied, reiterating his former statements, and answering the criticisms of Professor Lesquereux.[24] And finally Professor Heer, in an article published in May, 1861, defended his position, namely, that the plants are Tertiary rather than Cretaceous, if judged from the standpoint of European paleobotany.[25] This discussion added little to the settlement of the point at issue, and was at the time regretted by the gentlemen engaged in the controversy. Both Professors Heer and Lesquereux afterward came to accept the position of Doctor Newberry.

Meek and Hayden, in 1861, published a paper in which they in a general way discuss the geology of the entire upper Missouri region. In this paper they finally complete the section of the Cretaceous rocks first published in 1853, and which from time to time had been revised and elaborated. As completed, the section includes 2600 feet of strata, and is divided into the following groups, corresponding to the numbers formerly employed:[26]

No. 5.	Fox Hills beds	500 feet.
No. 4.	Fort Pierre group	700 "
No. 3.	Niobrara group	200 "
No. 2.	Fort Benton group	800 "
No. 1.	Dakota group	400 "

The description of the Dakota group, which for the first time bears that name, and in which we are particularly interested, is as follows: "Yellowish, reddish and occasionally white sandstone, with, at places, alternations of variously colored clays and beds and seams of impure lignite. Also silicified wood and great numbers of leaves of the higher types of dicotyledons; with casts of *Pharella? dakotensis*, *Axinella siouxensis*, and *Cyprina arenaria*."

The description of the locality is: "Hills back of the town of Dakota; also

21. Am. Jour. Sci., 28: 85-89.
22. Loc. cit., 29: 208-218.
23. Ibid., 434-436.
24. Loc. cit., 30: 273-275.
25. Loc. cit., 31: 435-440.
26. Proc. Phila. Acad. Sci., 1862, p. 419.

extensively developed in Dakota county, below the mouth of the Big Sioux river; thence southward into northeastern Kansas and beyond."

In the discussion of the Dakota group they say: "Although we still retain this as a distinct rock, our present impression is that it is only a subdivision or member of the Fort Benton group. Still, until more fossils can be obtained from it in the region of typical localities, the question whether or not it should take rank as a distinct formation must remain an open one. The position of the rock beneath the Benton indicates that it is certainly as old as that group, while the dicotyledonous leaves found in it prove that it cannot be older than the Cretaceous."

In 1863 Professor Marcou, for the first time, visited the Dakota sandstone. He was accompanied by the Italian geologist, Capellini. Collections of leaves were made at Tekamah, Blackbird hill, and at the mouth of the Big Sioux river. Although up to this time Professor Marcou had contended for the Jurassic age of the beds, he was now convinced that they were Cretaceous. In an article published in 1864, "Une Reconnaissance Geologique au Nebraska,"[27] this was frankly admitted. This practically ended the discussion, and settled one of the long-mooted questions of the geology of the West.

LESQUEREUX'S WORK ON PALEOBOTANY.

It was in 1866 that the descriptions of the leaves collected by Messrs. Marcou and Capellini were published, in a paper entitled "Les Phyllites Crétacées du Nebraska."[28] The account of the trip and description of localities were written by Professor Capellini, and the leaves were figured and described by Professor Heer. They include seventeen species, all of which are new. The article constitutes the first description of leaves from the Dakota; and from it nearly all the leaves since found in northeastern Nebraska have been identified.

While the age of the Dakota in its type locality, near Sioux City and Blackbird hill, was practically settled by the admission of Professor Marcou, the age of what is now known to be the same rock in Kansas was much longer a matter of doubt. Prof. B. F. Mudge, in 1866, described the finding of a fossil footprint in the Liassic (?), on the Republican river, about fifty miles from its mouth, and stated that the Triassic, Jurassic and Cretaceous were all represented in that part of Kansas.[29] Doctor Hayden, in speaking of the beds referred by Major Hawn to the Trias, says: "They may be Trias, Permian, or even Jurassic, as far as any evidence yet obtained goes. . . . We must await further evidence before we can regard the existence of Trias in eastern Kansas as demonstrated."[30] In 1869, however, Professor Mudge found marine invertebrates and dicotyledonous leaves in the same beds in Saline county, and referred the disputed formation to the Dakota.

Doctor Newberry published an article in 1868 describing the leaves collected by Meek and Hayden at various times and from various localities in the Dakota.[31] It was intended that an extended report of the leaves follow this article, and a series of plates was prepared awaiting this report, which was to constitute volume VIII of the Geological Survey of the Territories. The report, however, was never written, and in 1878 Doctor Hayden published a small edition of 500 copies of the plates.[32]

Leo Lesquereux, who afterward did more than any other man to further the

27. Soc. Geol. France, Bull., 2e ser., 21: 132-146.
28. Mem. de la Soc. Helvetique des Sci. Nat., 22, No. 1.
29. Am. Jour. Sci., 41: 174-176.
30. Loc. cit., pp. 32-40.
31. Annals Lyc. Nat. Hist. N. Y., 9: 1-76.
32. Illust. of Cret. and Ter. Plants, Washington, 1878, 27 pl.

work of phytopaleontology in America, became interested in the subject about this time. As early as 1856 he had observed fossil leaves in the sandstone near New Ulm, Minn.[33] Again, in 1859, his name appeared as a champion of the Swiss scientist in the Heer-Newberry controversy; but it was not until 1868 that his first contribution to the paleontology of the group appeared. It was entitled "On some Cretaceous Plants from Nebraska,"[34] and discusses fifty-three species, forty of which are considered new forms. This paper, published the same year as that of Doctor Newberry, was the first of a series by the same author. The material collected on the various expeditions of Doctor Hayden, as well as that sent from Kansas by Professor Mudge, John Leconte, Charles Sternberg, and others, was described in these reports.

In addition to this, Doctor Lesquereux himself visited the collecting grounds and secured a large number of specimens. He was in Kansas in 1873, and the next year visited both Kansas and Nebraska. The various species mentioned from time to time were figured in his "Cretaceous Flora,"[35] published in 1874. This was the most comprehensive report so far published. A short historical sketch is annexed, and the various phases of the Dakota group are discussed with a remarkable clearness and penetration. The views here first set forth are in general still accepted by American paleobotanists. As new material was collected, it was sent to Doctor Lesquereux for identification. This necessitated additional publications, and almost every year brought forth from his facile pen a contribution to paleobotanic literature. In 1876 he published an extended article, in which a number of new forms are described and figured.[36] Other articles followed, and in 1883 he published his "Cretaceous and Tertiary Flora," containing nearly 300 pages, accompanied by fifty-nine plates, seventeen of which are devoted to Dakota plants.[37] This was the second of the three monumental works on this group by this eminent scientist. During these years many collectors had been at work. Judge E. P. West, Prof. B. F. Mudge, H. C. Towner, Charles Sternberg and others had made extensive collections, especially in Ellsworth county, Kansas, where the Dakota reaches its typical development. The leaves collected were sent to several American universities, notably Harvard, and even to Europe. The largest collections, however, were secured for the University of Kansas and for the Smithsonian Institution. Practically all of these fossils were identified by Doctor Lesquereux, who continued to publish descriptions of the various new forms.

About 1885 he began his final work, a monograph entitled "The Flora of the Dakota Group." The manuscript of this work, containing about 500 written pages, and including descriptions of 350 species, was submitted to the publisher in February, 1888. Before it could be published, however, additional discoveries of leaves were made in Kansas and the specimens sent to Doctor Lesquereux for identification. Although in feeble health, he began the work with his characteristic enthusiasm. Finding much new material, he requested that his manuscript and plates be returned to him, in order that he might incorporate it in the monograph. In a short time he had identified and described 110 new forms, bringing the number of species in the Dakota up to 460. Before the figures were all drawn, however, Doctor Lesquereux died, October 25, 1889. The monograph, edited by Dr. F. H. Knowlton, was published in 1892.[38]

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33. Cret. Flora, p. 6.
34. Am. Jour. Sci., 46: 91-105.
35. Rept. U. S. Geog. Surv. Terr., vol. VI.
36. U. S. Geol. and Geog. Surv. Terr., Bull. No. 1, 2d ser., pp. 233-248.
37. U. S. Geol. and Geog. Surv. Terr., vol. VII.
38. U. S. Geol. Surv., Mon. No. 17.

INVERTEBRATES AND RECENT INVESTIGATIONS.

Another phase of the history of the Dakota group remains to be considered, and that but briefly. It is the question of invertebrates. From almost the first mention of the sandstone by Meek and Hayden the paucity of animal remains was constantly referred to. The overlying Benton was very prolific in shells, as was the subjacent Carboniferous. In the Dakota, on the contrary, few forms were found, and these in restricted localities. In the general section, published in 1870, only three species were mentioned from the Dakota, while the Benton is characterized by fifteen and the Pierre by more than twenty forms. The marine invertebrates referred to above, which were found in Saline county by Professor Mudge, were obtained from the lower part of the group, not many feet above the Permian. The shells were identified by Professor Meek. Other specimens were occasionally found in scattered localities, and were identified from time to time by Dr. C. A. White and others. The last of these descriptions by Doctor White appeared in 1894, and dealt with some shells from near Fairbury, Neb., found a little above the middle of the group.[39]

Meanwhile the investigations of Hill in Texas and Cragin in southern Kansas had demonstrated the presence of vast beds of Lower Cretaceous rocks in these regions.[40] In response to the invitation of Prof. A. W. Jones, of Salina, Kan., who had rediscovered the locality first found by Mudge in 1869, Professor Cragin visited Saline county, and in 1895 published a paper, in which he inclines to the opinion that the beds in central Kansas that are found at the base of the Cretaceous represent a northern extension of the Comanche or Lower Cretaceous of the Texas-Oklahoma regions.[41] The position taken by Professor Cragin now has the assent of practically all geologists who have studied the question.

In 1891 Dr. C. A. White published his "Correlation Papers on the Cretaceous," probably the most authoritative utterance so far written on the subject.[42] The Dakota horizon is regarded as a fresh-water deposit, constituting the basal member of the Upper Cretaceous. At that time, however, the deposit of its strata was not known to have immediately succeeded that of the Lower Cretaceous. These conditions have since been observed in several localities, notably in southern and central Kansas. Doctor White states that the Dakota is so well defined that no difference of opinion as to its identity, characterization and delimitation has ever arisen among geologists who have studied it in the southern interior region, *i. e.*, south of the Platte river. The opinion is also expressed that we must rely almost exclusively upon fossil plants for the paleontological characterization of the horizon.

During the last decade much work of permanent value has been done in the Dakota. Several publications of more than passing interest have appeared, but these must of necessity be passed by in this review. It may not, however, be inadvised to mention the names of Lester F. Ward, Erwin H. Barbour, T. W. Stanton, N. H. Darton, Robert Hay, Charles S. Prosser, J. W. Beede, S. W. Williston, G. K. Gilbert, Geo. I. Adams, C. A. Fisher, W. N. Logan, F. W. Cragin, and A. W. Jones, all of whom have, either directly or indirectly, added to our knowledge of the Dakota Cretaceous of Kansas and Nebraska.

GEOGRAPHICAL DISTRIBUTION.

INTRODUCTION.

It is not the province of this article to discuss the Dakota group beyond the limits of the states of Kansas and Nebraska, except the small area near Sioux City, in northwestern Iowa, and this only because of its early connection with

39. Proc. U. S. Nat. Mus., 17: 131-138.
40. Am. Jour. Sci., 50: 205-234. Also, Am. Geol., 16: 357-385.
41. Am. Geol., 16: 162-165.
42. U. S. Geol. Surv., Bull. No. 82.

the literature of the group. Passing by the exposures which are known to occur in Minnesota, South Dakota, Wyoming, Colorado, Oklahoma, New Mexico and other states, I shall at once proceed to consider the Kansas-Nebraska outcrops of the Dakota.

In general, the formation as exposed in the region extends in a line from Sioux City, Iowa, to Ashland, in southwestern Kansas. The distance as the crow flies is not far from 500 miles. The width of the group, as exposed, probably averages about thirty-five miles, although places may be found where the distance from the eastern to the western limits is to exceed eighty miles. Both the lower and upper lines of outcrop are exceedingly irregular. The subjacent formations extend far up the valleys, and in places approach within a few miles of the Benton, which, resting on the Dakota, caps the hills to the west. A good example of this fact may be seen in western Saline and eastern Ellsworth counties, Kansas. From Brookville, which is near the top of the Permian, to the noted cave section, on the hills back of which the Benton may be found, is less than ten miles, although in the intervening country may be found some of the roughest and most typical Dakota in the two states. Another instance is near the Kansas-Nebraska line. The Permian is found as far up the Little Blue river as Steel City; while the Benton on the hills to the west is not more than six miles distant.

In the following discussion I shall consider that the line of unconformity at the base of the Cretaceous rests, respectively, on three phases of the Upper Paleozoic rocks: Upper Carboniferous, Permian, and Triassic; that the horizons just mentioned are conformable throughout; that the Comanche series, or Lower Cretaceous of Kansas, is found only in the southern and central parts of the state; that it consists of two formations—the Cheyenne sandstone, confined to the Belvidere locality, and the Kiowa shale, known in the central part of the state by the term "Mentor Beds"; that the Dakota rests conformably on the Lower Cretaceous wherever the latter is exposed; and that it passes conformably above into the Benton, which consists of shales and fossiliferous limestones. These topics are treated at greater length under their proper head, stratigraphy, and are introduced here simply in order that the subject may be understandingly read.

In order to simplify the discussion of the various outcrops, I have divided the entire region into three areas, viz.: The southern Kansas area, the Smoky-Blue area, and the Nebraska area. The first of these occurs in southwest Kansas, and contains the following four localities: Belvidere, Clark county, Cimarron-Bear, and Arkansas localities. The second area extends from the Arkansas river, at Great Bend, to the Big Blue river, near Beatrice, Neb. In the discussion it will not be subdivided. The third area, which lies for the most part in eastern Nebraska, consists of the Salt Creek, Platte, Missouri, and Big Sioux localities. This division differs essentially from that of Doctor White, who includes in his "Southern Interior" region all the formations south of the Platte river, and in the "Northern Interior" region all lying north of this stream. It is obvious that both of these divisions are purely arbitrary, and have been adopted simply as a convenient schedule of classification. My divisions, in particular, are purely local, and are nothing but convenient groupings for purposes of discussion.

The exposures of the Dakota of the first or southern Kansas area are overlaid by the Tertiary, and grade conformably upward from the Comanche. The Dakota of the second area rests conformably on the Comanche, or unconformably on the Permian, and is capped with the Benton, except in southern Nebraska, where

Glacial deposits have protruded. The rocks of the third area rest on the Permian and Carboniferous and are covered by the Benton and glacial.

The limit of glacial deposits cuts the strike of the Dakota nearly at right angles not far from the Kansas-Nebraska state line. The line of boulders indicating the position of the terminal moraine enters Kansas near Kansas City and follows roughly the course of the Kansas, Blue, and Little Blue rivers, usually extending a few miles south of these streams. The northeastern corner of Washington county, Kansas, is covered with the characteristic drift boulders, and in places by the loess. Southwestern Jefferson county, Nebraska, just across the state line, is beyond the line of drift. The largest exposed area of Dakota in Nebraska is in this locality. In all other parts of this state exposures occur only along bluffs, or as isolated points where post-glacial erosion has removed the later deposits. It has been estimated that, although the Dakota in Nebraska originally covered what would constitute more than twenty counties, the total amount of visible exposures, if grouped together, would not comprise a single county the size of Lancaster or Gage.

SOUTHERN KANSAS AREA.

Belvidere Locality.—This locality is chiefly known as being the type locality of the Comanche series of southern Kansas. Some of the geologists who have visited this region are Cragin, Hill, Prosser, Ward, and Stanton. All of these gentlemen have noticed the presence of Dakota-like boulders and ledges on many of the hills in the vicinity. To this rock Professor Cragin gave the name "Reeder sandstone." In 1897 Dr. Lester F. Ward and the writer first worked out the relations of the Comanche to the superjacent beds.

The Comanche of the region consists of two distinct formations. Resting unconformably on the Red Beds is the Cheyenne sandstone, consisting of rather fine-grained, variously colored sandstone with intercalated beds of shale, often carbonaceous, and containing an abundant flora, chiefly dicotyledonous. The extreme thickness of the Cheyenne is between forty and fifty feet. Resting conformably upon the Cheyenne is the Kiowa shale, a marine deposit consisting of about 150 feet of dark blue to black papyraceous shale, with occasional layers of soft, sandy shale and of hard limestone. The fossils consist of invertebrates, including insects, numerous mollusks, and vertebrates, with reptilian forms predominating. In the paper containing the results of the investigations made in 1897,[43] mentioned above, the term "Medicine Beds" was applied to a series of transition beds supposed to be intermediate between the Comanche and the Dakota. (See pl. IV.)

At the time the paper was written it was not known that fossils were present in the beds. Doctor Stanton has since found shells which do not differ from those in the underlying Kiowa nearly as high as the Dakota. In view of this fact, it would, perhaps, be better to discard the term "Medicine Beds" and class all the strata in either the Comanche or the Dakota, although the exact line of demarkation can scarcely be drawn. This brief description of the Comanche of the Belvidere locality has been introduced here because of the fact that this is the basal formation of the Cretaceous of the two states. The literature of the subject is ample and will repay perusal.[44]

The best exposures of Dakota in this region are on the upper Medicine river, ten miles west of Belvidere and about the same distance south of Greensburg, Kan. The rock is the typical brownish-red sandstone, containing great numbers

43. Am. Jour. Sci., 5: 169-175.

44. See Charles S. Prosser's resume, Univ. Geol. Surv. of Kans., 2: 96-111. Also "The Lower Cretaceous of Kansas," Am. Geol., 25: 12-26.

of ironstone concretions. Rather poorly preserved dicotyledonous leaves are found in a few ledges. Other exposures of the sandstone are at Blue Cut mound, two and one-half miles south of Belvidere, and on the high hill south of the forks of the Medicine river, five miles west of the same place. The sandstone is everywhere covered unconformably by the Tertiary, and doubtless extends under this covering west to Clark county and north to the Arkansas river.

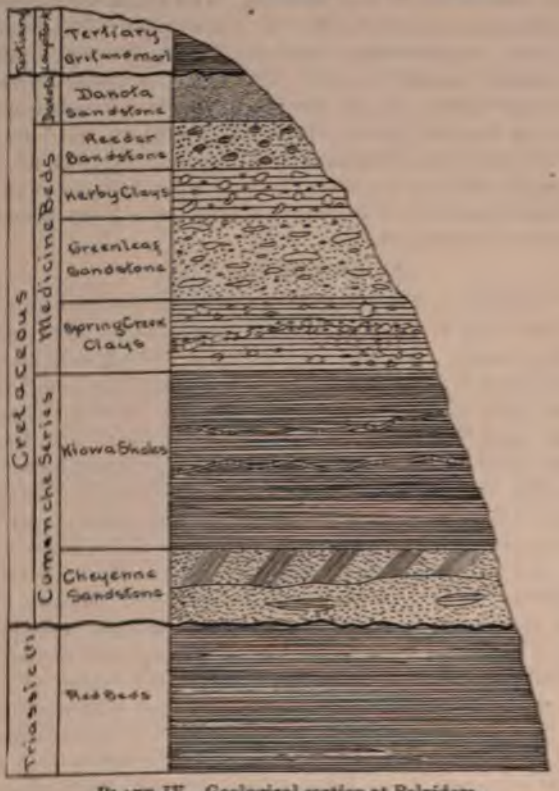


PLATE IV. Geological section at Belvidere.

Clark County Locality.—The general features of the Cretaceous of Clark county do not differ from those of Belvidere, except that here the Cheyenne is wanting. The base of the Kiowa rests unconformably on the unevenly eroded surface of the Red Beds. The fossils and stratigraphy of the Kiowa are very similar to the Belvidere locality, with the exception that in Clark county there is usually a greater proportion of arenaceous shale in the upper layers. The Kiowa grades upward through the more or less pronounced transition beds into the typical dark-brown and black Dakota sandstone. The outcrops of the Dakota occur in a line from northeast to southwest for a distance of twenty miles, from Bluff creek, ten miles north of Ashland, across the head of Hackberry, East Bear, West Bear, Chatman, Big Sand, and Kiger creeks, as far as the Little Basin, in the western part of the county. These creeks cut the line of outcrops nearly at right angles. Professor Cragin reported forty feet of dark-brown sandstone from the head of West Bear creek. At the same place Professor Prosser measured seventy feet. In 1898 Doctor Ward, Doctor Stanton and the writer

made a section on Cheyenne cañon, a tributary to upper West Bear creek, in which the distance from the Kiowa to the Tertiary was found to be 145 feet. Of this thickness, twenty-five feet was sandstone and the rest clay shales. Ironstone concretions are abundant in all parts of the formation, and by their prevailing dark-brown color render the slopes conspicuous for long distances. In this locality leaves were found in nearly every horizon above the Kiowa, becoming more abundant in the upper layers. On the east bank of Chatman creek, not more than a mile from Cheyenne cañon, the first leaves collected in the locality were found by Doctor Ward, in 1897; and from this place the best collections of the region have been obtained, although dicotyledons have been found in greater or less abundance in every outcrop in the county.

The Cimarron-Bear Locality.—Under this head have been included a number of isolated exposures of the Dakota in the extreme southwestern part of the state. These deposits of sandstone are cut off from the other outcrops of this group by more than 100 miles of Tertiary. It is along the bluffs in the valleys of Bear creek (which must not be confused with Bear creek in Clark county) and the Cimarron river and their tributaries that the dark-brown sandstone outcrops. Point of Rocks, in Morton county, a line of bluffs on Bear creek, in Stanton county, and several exposures between these, on the North Fork of the Cimarron, are referred to this group. The line of outcrops extends beyond the limits of the state into Colorado. For the most part, the rock is soft, rather light brown in color, and contains much clay shale. It is in demand for building purposes only because it is the only rock found in the region. Leaves are reported from the bluffs of Bear creek, and persistent search can scarcely fail to be rewarded in a formation that is so uniformly fossiliferous.

The Arkansas River Locality.—Along the Arkansas river, from Dodge City to Great Bend, a line of low bluffs runs parallel to the river on the north side. These bluffs are composed of Dakota sandstone, and are capped by the Tertiary. They are, in most places, from two to five miles back from the river; in one place only does the river wash the bluff. This is three miles east of Ford City. At but two points are the bluffs in any way conspicuous: at Pawnee Rock and at Jenkins bluff, near Larned. Pawnee rock, on the old Santa Fe trail, is a bold shoulder projecting into the valley. The rock in this locality is quite hard, sometimes almost quartzitic, and is being blasted away to furnish building stone. Pawnee rock covers perhaps an acre, and the face of the cliff is some thirty feet high. From its top a narrow ridge runs back half a mile or more to the main line of bluffs. This spot is famous for the tales of terror connected with Indian massacres.

Near Larned, on the north side of the Pawnee river, the sandstone forms a number of prominent bluffs. The most conspicuous is Jenkins bluff, three miles west of the city, near the site of old Fort Larned. This hill is about 150 feet high, and exhibits the usual sequence of shales and sandstones. Fossil leaves are found both at this place and at Larned. The sandstone bluffs extend for a number of miles up Pawnee river and Walnut creek, both of which enter the Arkansas from the north. Toward Great Bend the line of bluffs recedes from the river, and the sandstone finally disappears beneath the Upper Cretaceous deposits on the divide between the Arkansas and the Smoky Hill.

SMOKY-BLUE AREA.

Under this head will be included all the region that drains into the Kansas river. The line of outcrops here, as in other localities, runs northeast and southwest. Six principal tributaries of the Kansas, flowing southeast, cut this line

approximately at right angles. Beginning on the south these streams are Smoky Hill, Saline, Solomon, Republican, Little Blue, and Big Blue. Where they break through the line of hills all of these streams have cut rather narrow valleys in the sandstones and shales. In this regard they are in marked contrast to such streams of the plains as the Arkansas, Ninnescah, Platte, or Loup which have broad and shallow valleys. This area constitutes the most typical section of the Dakota group. It is here alone that the entire thickness of strata from the underlying Permian to the superjacent Benton may be seen throughout any considerable area. The topography also differs materially from that of other regions. It is characterized by bold cliffs, flat-topped buttes and mesas, square shoulders and ledges, interspersed with steep slopes and here and there narrow cañons. This angularity of topography contrasts strangely with the gentle rounded slopes of the Benton or Permian. The conditions indicated obtain for the greater part of the area. South of the Smoky Hill river the Dakota is covered by the Benton or by the Tertiary; and the asperity of bluff and butte is much subdued. The same is true of the country between the Little Blue and Big Blue rivers, where glacial deposits have protruded. In this locality the outcrops are confined to bluffs near the streams where erosion has removed the later deposits.

The area under consideration is about 100 hundred miles long, with an average width of perhaps thirty miles. The greatest width is not far from sixty miles extending from the high hills in western Marion county, where the base of the Dakota first appears, along the Smoky Hill river to a point in southern Russell county, where the last trace of the Dakota disappears under the Benton. This extreme width is due to two causes: the outlier of the Dakota, which in Marion county extends far east of the main body, and the long tongue of sandstone which follows for a great distance up the valley of the Smoky Hill. Similar tongues follow the valleys of all the streams mentioned above. On the other hand, the shortest distance from the Permian is less than ten miles, as at Brookville, Kan., or on the state line, as mentioned above. The outcrops of the Dakota in this area occupy portions of the following counties: Barton, Rice, McPherson, Marion, Ellsworth, Saline, Lincoln, Ottawa, Mitchell, Cloud, Clay, Republic, and Washington, Kansas, and Jefferson and Gage, Nebraska.

NEBRASKA AREA.

Salt Creek Locality.—All the exposures of this locality are in Lancaster county, Nebraska, except a few that are just across the Seward county line near Pleasantdale. In nearly every instance these exposures occur on the bluffs along the valleys of Salt creek and its tributaries. They are usually quite restricted in area, often occupying but a few hundred square yards. The greater part of the outcrops occur within a few miles of Lincoln, although outliers are found at a distance of from ten to twenty miles in every direction. Near Roca and Bennett, in the southeastern part of the county, the Dakota is found within a few feet of the Permian; although in no instance has actual contact been observed. The most eastern exposure is at Bennett, where there is a thirty-foot vertical cliff of the Dakota capped by ten feet of Drift boulders. (See plate V.) The Carboniferous (or Permian) limestone is exposed both north and south of the Dakota on a level several feet higher than the top of the sandstone. This furnishes a good example of the conditions so often observed throughout the Dakota area where the sandstone has been deposited in eroded hollows of the old Carboniferous floor.

Wells in the vicinity of Lincoln reach the Carboniferous limestone at a depth of 270 feet. The Benton limestone near Milford is about 100 feet above the alti

Ledge of Dakota sandstone, hill south of the penitentiary, Lincoln, Neb.
Photo by Jeffords.

tude of Lincoln. This would indicate that the thickness of the Dakota in this locality is between 350 and 400 feet, which agrees well with the thickness in other localities. A recent publication by Mr. N. H. Darton, of the United States Geological Survey, gives a much more comprehensive report of the Lancaster county outcrops.[45]

The Platte Locality.—This is the only locality in the Nebraska area where the nonconformity between the Carboniferous and the Dakota may be seen. The outcrops occur on both sides of the Platte river, from Plattsmouth to Fremont, a distance of fifty miles. The fact of the extreme irregularity of pre-Cretaceous erosion is here well exemplified. One of many examples may be cited on the north side of the river, nearly opposite Louisville, where two instances of non-conformity, not more than a quarter of a mile apart, differ eighty feet in altitude.

The numerous limestone quarries along the river usually exhibit more or less of the Dakota between the Carboniferous below and the glacial above. In this case there are of course two nonconformities: the first between the Carboniferous and Dakota, and the second between the Dakota and the drift. Often the lines of the two non-conformities are but a foot or two apart, indicating that during preglacial time the sandstone was almost entirely removed by erosion. In other places the Dakota has all disappeared and the drift rests directly upon the unevenly eroded Carboniferous limestone. Again, the sandstone forms high cliffs, as at the Santee caves, opposite Ashland. The most westerly exposure known in the locality is a small outcrop in the bluff where the west road leaves the river, two miles south of Fremont.

The Missouri Locality.—From Omaha to Ponca is 120 miles. Between these two places, along the bluffs on the west bank of the Missouri river, the Dakota is exposed almost constantly. In places the mantle of loess covers the sandstone to the depth of several feet, and the latter may not be exposed for miles. Usually, however, the more or less conspicuous outcrops may be seen half way up the slope. Not infrequently the presence of springs issuing from the loess indicate that the water-bearing Dakota lies just beneath the surface.

In the northern part of the locality, near Homer, Jackson, and Ponca, the upper part of the bluffs are composed of Benton limestone. At the High banks, a mile north of Decatur, at Blackbird hill, and at the old mission, the Missouri washes cliffs of Dakota sandstone. It was these bluffs standing boldly out into the river that caught the attention of the early explorers. Much historical interest attaches to these places. This is not only the type locality of the Dakota, but is also the region concerning which the early controversy waged, and the place where the question was finally settled.

Big Sioux Locality.—Under this head are included the exposures east of the Missouri river, near Sioux City, Iowa. At Riverside park, on the east bank of the Big Sioux river, a mile from its mouth and three miles from Sioux City, the following section was taken illustrating the position of the beds:

No. 6.	Loess	10–100 feet.
No. 5.	Drift	5 "
No. 4.	Thin limestones and shales, Benton	5– 10 "
No. 3.	Yellow, blue and gray shales and clays, containing shells and concretions	60 "
No. 2.	Heavy ledge of sandstone containing leaves	15 "
No. 1.	Slope from Big Sioux river	20 "

No. 2 is quarried for building stone and from No. 3 clay is obtained for several brick and tile works. The exposures of both Dakota and Benton are said to

45. Water Sup. and Irriga. Papers, U. S. Geol. Surv., No. 12, pp. 16-19.

extend for a number of miles up the Big Sioux river. At Sioux City an exposure may be seen at Prospect hill, a bold bluff on the bank of the Missouri.

From this place the river crosses the broad valley and strikes the bluffs on the west side at the old mission, some twenty miles below. On the east side the bluffs trend to the southeast. A shoulder standing boldly out toward the river has received the name Sergeant's bluff, in honor of Sergeant Floyd, a member of Lewis and Clarke's party, who was buried on its summit. It is on the face of this bluff that the Dakota clay, which is very similar to that at Sioux City, is being excavated for brick and tile. The exposure is a quarter of a mile long, and the total thickness of the beds is said to exceed fifty feet. A considerable portion, however, consists of sandstone arranged in lenses and pockets; and near the top is a rather heavy sandstone ledge. Numerous leaves are found in some reddish-brown concretions scattered throughout the shales.

For maps showing the exposures of the Dakota in Kansas and Nebraska, reference is made to the University Geological Survey of Kansas, vol. II, pl. XLVII, for the Kansas areas, and to the Nineteenth Annual Report of the United

PLATE VI.

States Geological Survey, part IV, pl. LXXXII, for those of Nebraska. The first map is by Haworth and the second by Darton. The foregoing reduced map of the two states is intended to show graphically the exposures throughout the entire region discussed in this article. The stippled portions indicate Dakota areas.

STRATIGRAPHY.

LINE OF UNCONFORMITY.

The line between the Paleozoic and the Mesozoic rocks in Kansas and Nebraska is one of unconformity. The Triassic and Jurassic rocks are totally wanting, unless they are represented in the upper part of the Red-beds of Kansas and Oklahoma.[46] The Carboniferous rocks in the eastern part of the two states grade upward through the Permian to the point of unconformity. From this line the Cretaceous formations succeed each other in regular sequence to the western limits of the states, and far beyond. The rocks of both great eras, Paleozoic and Mesozoic, thicken to the south. On the Oklahoma line there are some 2200 feet of strata between the upper part of the Carboniferous and the base of the Cretaceous. At the Kansas-Nebraska line there are not to exceed 200 feet, while at the mouth of the Platte river the Dakota rests directly upon the upper surface of the eroded Carboniferous. In the Belvidere region the Cretaceous rocks below the base of the Dakota measure 250 feet, in central Kansas they are not more than 100 feet thick, while at the Nebraska line the Dakota rests directly upon the Permian.

In other words, there are on the Oklahoma line about 2500 feet of strata between the top of the Carboniferous proper and the base of the Dakota, while on the Platte river these beds have been entirely eroded away and their place is represented by a hiatus; the sandstones of the Dakota resting upon and filling up the hollows of the old Carboniferous floor. This fact was commented upon by Doctor Hayden, who, although he had not all the facts at command, yet lays especial emphasis on the uneven erosion of the Carboniferous during Triassic and Jurassic time. Beyond the limits of the territory discussed in this article the amount of pre-Cretaceous erosion is still more strongly marked. In Iowa the brown, leaf-bearing sandstone rests unconformably upon the middle, or perhaps the Lower Carboniferous, and in Minnesota the Dakota is found in the hollows of the Trenton or even of the Cambrian.

The superjacent strata are also quite varied. In the southern part of the area the Dakota is covered with the Tertiary. In McPherson county, Kansas, the Equus beds cap the group south of the Smoky Hill river. From near the state line throughout the entire state of Nebraska, all the older formations are covered with a mantle of glacial deposits. All of these rest unconformably upon the Dakota. From the Arkansas river to Iowa the Dakota is everywhere superseded conformably by the Benton and this by the Niobrara.

Plate VII shows the relative position of the various formations contiguous to the Dakota in Kansas and Nebraska. Continuous lines represent unconformity.

BASE OF THE DAKOTA.

A question which might prove a vexing one, did we permit ourselves to consider it such, is that of the line of separation of the Dakota from the sub- and superjacent Cretaceous groups. At first glance it would seem necessary that a

46. Since the above was written, it has been demonstrated that the upper part of the problematic Kansas-Oklahoma Red-beds is Triassic. Vertebrates taken from the lower part of these beds, in eastern Oklahoma, have been identified by Dr. S. W. Williston as Permian forms, similar to those from the Texas Permian. On the other hand, invertebrates obtained from near the top of the Red-beds in western Oklahoma are classed as Triassic forms, on the authority of Dr. J. W. Beede and Mr. Charles Schuchert. The line of separation between the two series of rocks has been drawn provisionally at the heavy ledge of gypsum that caps the Gypsum Hills of Kansas and Oklahoma. See First Biennial Report of the Oklahoma Geological Survey.

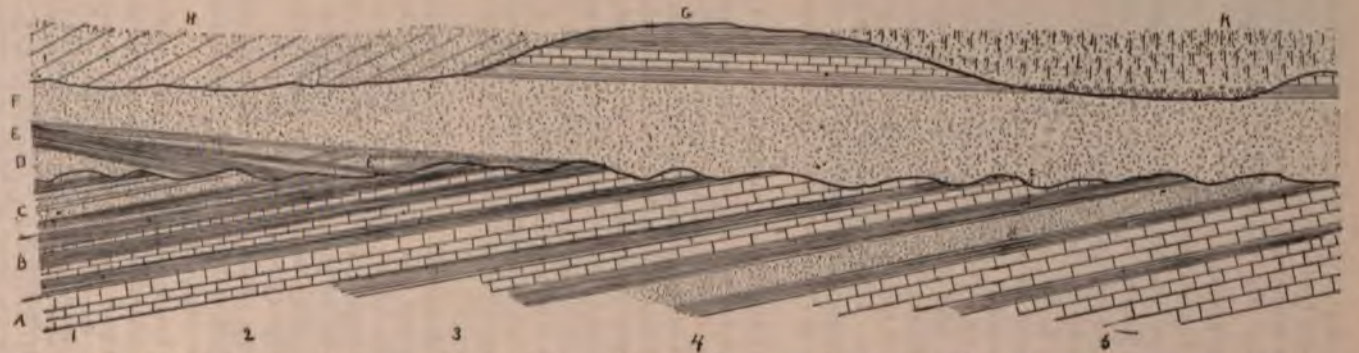


PLATE VII.—Geological section, showing unconformities below and above the Cretaceous along the line of Dakota outcrop in Kansas and Nebraska.

Formations.	Conditions and Unconformities.	Formations.
A = Carboniferous.	1. At Belvidere—Cheyenne unconformable on the Red Beds.	E' = Mĕntor.
B = Permian.	2. In Clark county—Kiowa unconformable on the Red Beds.	F = Dakota.
C = Red Beds.	3. In Saline county—Mentor unconformable on the Permian.	G = Benton.
D = Cheyenne.	4. At State line—Dakota unconformable on the Permian.	H = Tertiary.
E = Kiowa.	5. On Platte river—Dakota unconformable on the Carboniferous.	K = Glacial.

fixed line be drawn in order sharply to define the limits of the various formations. This, however, it seems difficult to do.

It should be remembered that Doctor Hayden, who named and described the group, did not at that time know of the existence of older Cretaceous rocks in the west; but supposed that the Dakota was the basal member of the Cretaceous and rested in all places directly upon the Carboniferous or Permian. It is the presence of Lower Cretaceous formations immediately beneath the Dakota that seemingly complicates the problem. In regard to the upper limits of the group, Doctor Hayden frankly admits that there is great difficulty in drawing the line between the Dakota and the Benton, because of the fact that both the stratigraphy and fossils of the two groups blend in numerous localities. In speaking of the exposures near Sioux City, he says: "Lithologically, it is impossible to draw the line between these formations here. No. 1 (Dakota) passes so imperceptibly into No. 2 (Benton), and No. 2 into 3 (Niobrara), that there is no break, and yet their principal characteristics are very distinct. The first is a sandstone, the second a black, plastic clay, and the third a chalky limestone; and yet I cannot tell the exact point where one commences and the other ends."

If this be true for the line between the Dakota and the Benton, what shall be said of the base of the Dakota, where conditions are much more complicated? As far as the observations of the writer go, it is rarely difficult, in any one of the dozens of localities he has visited in Kansas, Nebraska, and Iowa, to decide upon a line of separation, at least approximately, between the Dakota and the Benton. The sandstones of the former group gradually thin out, yellowish arenaceous shales become prominent, these become darker and more argillaceous, and are succeeded, at a distance of from fifty to eighty feet above the last sandstone, by the typical *Inoceramus* limestone so characteristic of the Benton.

The conditions at the point of separation of the Comanche and Dakota are quite different. In the localities where the best exposures of rocks of both these series occur, Belvidere, and Clark county, Kansas, the upper member of the Comanche, known as the Kiowa shale, consists of about 150 feet of dark, papyraceous shale, usually becoming arenaceous above. This shale contains a characteristic marine fauna, both vertebrate and invertebrate, which is frequently less abundant in the upper layers. Before the fossils disappear, the shales are, in places, superseded by ledges of sandstone more or less massive, and as much as fifty feet thick. In other places no fossils are found above the shales. The sandstone ledges become more pronounced and soon begin to contain a dicotyledonous flora.

In central Kansas similar conditions obtain. As has been stated, in this region the rocks which occupy the lower part of the Cretaceous groups were first classed as Triassic, then Jurassic, then Dakota, then called "Mentor beds"; and are now recognized as representing the northern limit of the Comanche or Belviderean sea. Paleontologically, these measures differ but little from the Kiowa of southern Kansas. Stratigraphically, the rock is very like the Dakota, or, rather, it combines the characters of the Kiowa and Dakota. In a section taken near Marquette, Kan., which is probably typical as regards stratigraphy, there are twenty-nine feet of sandstone and seventy-six feet of shale.[47] The shale predominates in the lower part of the section, where it is very like the Kiowa. Above, sandstones occupy the greater part of the thickness. The upper stratum in the section is a heavy ledge of rather hard, dark-brown sandstone, which contains an abundant Mentor fauna, of which Doctor Stanton has recognized twenty-two forms. Fifty feet below this ledge is a layer of soft sandstone

47. American Geologist, 25:35.

containing Dakota leaves. From this ledge the following species have been recognized: *Sterculia* sp., *Eucalyptus dakotensis* Lx., *Myrica longa* Lx., *Salix proteæfolia* Lx., *Sequoia* sp., *Sassafras cretaceum* Newb., *Sassafras mudgei* Lx.

It is the fact of the overlapping of the Dakota leaves and the Comanche shells that seemingly complicates the problem of the line of separation, which, from the standpoint of stratigraphy alone, is sufficiently vexing.

Professor Mudge states that he found shells and leaves in the same ledge. This condition has not been noticed by the writer, but there is no reason to doubt the correctness of the statement. The Kiowa and its synonym, the Mentor, are evidently deep-sea deposits. At the close of Comanche time, and especially in the northern part of the area, the sea bottom was probably raised nearly out of the water. Many islands appeared. Numerous inlets, bays, bayous and lagoons were formed. Neither was the elevation constant. Depressions occurred, and marine shells flourished in the deeper bays. South of Mentor, Saline county, there is a ledge of oyster shells two feet thick. In the brackish- and fresh-water lagoons and inlets such forms as *Unio* predominate. A locality five miles north of Salina yields only fresh- and brackish-water forms. The islands were covered with dicotyledonous trees. The leaves blown off by the wind or falling in the course of nature were washed about by the tides and currents, sometimes being deposited near the shore, and again being carried into deep water. As the land was raised more and more the marine shells gradually perished, and only brackish-water forms remained. These are occasionally found throughout the entire group. In the upper part of the formation, after something like 300 feet of strata had been deposited, the increasing number of invertebrates, as well as such lithological phenomena as saliferous shales and lignites, herald the subsidence of the surface preparatory to Benton sedimentation. This group contains a marine fauna quite distinct from that of the Comanche.

As was remarked above, in the southern Kansas areas the question is considerably simplified. The Kiowa grades upward through a series of beds more or less transitional in character into the true leaf-bearing Dakota. As far as known, the thickness of the strata, from the upper layer yielding invertebrates to to the lowest sandstone containing leaves, is nearly 100 feet. Doctor Ward rightly considers these transition beds the true base of the Dakota group. This would be equally true of the central Kansas region. The fact of the overlapping of the fossils may be considered accidental, or rather incidental, depending on the peculiar conditions surrounding the deposition of the material.

In view of these facts, it does not seem either necessary, expedient, or possible, in the present state of our knowledge, to fix an arbitrary line of separation between the Comanche and the Dakota. The conditions, as outlined above, are such that such an attempt at a fixed demarkation limit is at least impracticable. Taking Meek and Hayden's classic section as a criterion, the base of the Dakota would probably be placed at the lowest sandstone ledge. The invertebrate paleontologist might be tempted to squeeze the Dakota into the narrow limits between the shell-bearing horizons, the one at the base and the other in the upper part of the group; and, on the discovery of shell beds throughout the formation, to draw a line near the middle of the group, and, calling all below this line Comanche and all above Benton, to eliminate the Dakota entirely. The vertebrate paleontologist would probably draw the upper limit of the Comanche at the highest stratum yielding vertebrate remains. The phytopaleontologist may perhaps be pardoned for insisting that the lines of demarkation of a group characterized almost exclusively by plant fossils be determined by the same criteria.

GENERAL CHARACTER OF STRATIGRAPHY.

To the cursory observer traveling through central Kansas or along the "Bench road" from Tekamah to Decatur, Neb., it might appear that sandstone ledges occupied the greater part of the Dakota group. The most conspicuous objects are bold and rugged shoulders, buttresses, and cliffs of massive sandstone. This sandstone is of all shades of color, from gray to black, with brownish red predominating. The ledges may, in fact, be traced for miles, forming the escarpment of a ridge or outcropping as a definite ledge along the side of a bluff. Such geologists as Hayden and Capellini seemingly failed to recognize the fact, or at least did not record it, that the greater part of the Dakota group is not sandstone, but consists of sandstones and shales. At a conservative estimate, at least two-thirds of the rock of the group is not sandstone. It is true that in many places they are strongly arenaceous, but not enough so to constitute them sandstones.

The shales and clays of the Dakota vary much both in texture and color. Not infrequently they are black and papyraceous, reminding one very much of the Kiowa. Usually, however, they are white, blue, or yellow, with many bands of red or green. A Dakota clay bank ordinarily presents a variety of colors. The darker shales are usually more highly argillaceous; while the lighter colors, such as yellow and gray, indicate a greater amount of sand. Another fact that should not be allowed to escape notice in a systematic study of the group is the non-continuity of both sandstones and shales. There are almost no persistent ledges of hard rock with shales between, as is the case in either the Permian or Benton. For example, the Cottonwood limestone, near the top of the Carboniferous, is persistent for over 200 miles; and in the Benton the "fence-post limestone" may be traced perhaps half as far. Nothing like this occurs in the Dakota. It is true that in a few instances pronounced ledges may be traced across one or two counties. As examples may be cited the ledge along the Missouri river below Sioux City; also the ledge which caps the Smoky Hill buttes and Soldier Cap mound, in Saline county, Kansas, and forms the escarpment along Spring creek, above Brookville, as far as the Ellsworth county line. (See plate VIII.) Even these ledges, however, which are exceptions to the general rule, vary much in thickness.

Throughout the group the sandstone is not constant in lithological qualities. It represents all degrees of hardness, from very soft sand, which may be crushed with the fingers, to the hard, brittle, clay-ironstone concretions, which turn the edge of the hardest steel. A bank of argillaceous shale will oftentimes become arenaceous, change to soft sandstone, and this, in turn, become hard enough to form conspicuous ledges; all in less than 100 yards. Not infrequently these changes may be observed several times in the course of a few miles, the ledges appearing and disappearing with no apparent regularity.

Massive and conspicuous ledges are not uncommon. Doctor Hayden assigns to the ledge above Blackbird mission the thickness of from sixty to eighty feet. At Tekamah, Neb., it is over fifty feet from the bed of Tekamah creek to the top of the railroad cut; and the entire thickness is through the coarse, dark brown sandstone. At the Santee caves, on the Platte, a sixty-five foot ledge is exposed. On Mulberry creek, in eastern Ellsworth county, Kansas, a mile east of the famous cave section, a ledge measures seventy feet; and at the mouth of Alum creek, ten miles south, is one nearly as thick. These, however, are exceptions. Ten feet would, perhaps, be a fair average for the thickness of Dakota ledges.

The strata of clays and shales are usually much thicker; but because of the fact that they are composed of softer material are more easily denuded. A

covered grassy slope is ordinarily indicative of a shale bed; and it is but necessary to notice how large a per cent. of the Dakota area is occupied by these covered slopes, in order to get a tolerably correct idea of the amount of shaly material contained in the group. It is because of the fact that the shale is covered that it has so persistently escaped notice. It should, perhaps, also be noticed in this connection that in many, perhaps most, cases these covered slopes are strewn with boulders and fragments of rock from the ledges above. These often give the slope the appearance of a rocky ledge, when the underlying strata consist of shale and clay.

Mr. Logan distinguishes two general groups in the Dakota: a lower or ferruginous group, and an upper or saliferous group. The upper group is divided into a lignite horizon, a salt-marsh horizon, and a gypsiferous horizon.[48] It is not the understanding of the writer that Mr. Logan intended these as general divisions of the entire group, but rather for that part which he studied, viz., the area between the Smoky Hill and the Republican rivers. The conditions noted by Mr. Logan obtain for the region described by him, but are not characteristic of the entire group. Saliferous shales and lignites seem to be found rather more abundantly in the upper than in the lower beds; but even this statement must be considered general rather than specific. After four years spent in studying the various horizons, from Oklahoma to Minnesota, the writer is reluctantly forced to the conclusion that any persistent or general division of the Dakota group is not only impracticable, but, in the light of our present knowledge, impossible. That he would prefer it otherwise will be apparent from the discussion of the flora of the group. In this connection a quotation from Doctor Lesquereux seems pertinent:

". . . The whole group bears, with scarcely any change in the nature and compound of its strata, the same essential character, from the lowest strata to the line of conjunction with the Fort Benton above it. . . . The compound is essentially the same in the whole thickness and in the whole extent, varying only in the degree of hardness, compactness, and red coloring resulting from the different proportions of oxide of iron with which it is impregnated."[49]

ORIGIN OF DEPOSITS.

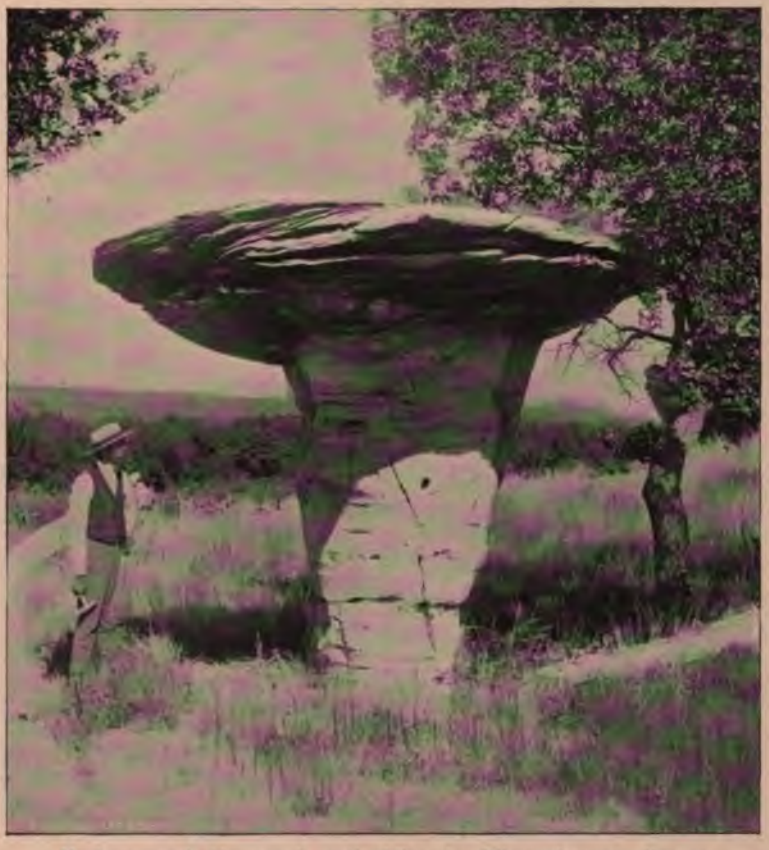
There has been no little diversity of opinion regarding the origin of the material, and especially the conditions incident to the deposition of the Dakota group. Professors Capellini and Marcou considered the formation a fresh-water deposit. This was due to the small proportion of calcium contained in the rock, as well as the general paucity of marine fossils. Meek and Hayden, who had better opportunities for observation, considered the beds marine; and in proof of their position cited the presence of a few marine invertebrates in the upper beds at Sioux City.

The fossils found in Kansas in what are now known to be Lower Cretaceous horizons were also taken as evidence that the beds were of marine origin. Doctor White, on the contrary, was disposed to consider the group in general as non-marine. There are grave difficulties in either position. The extent of the group and the homogeneity of its constituent parts would seem to vitiate the theory of fresh-water origin. It is very unlikely that a fresh-water deposit would cover an area the size of the Dakota. On the other hand, the dicotyledonous flora, the absence of limestone and the extreme scarcity of marine shells throughout the greater part of the group preclude the idea of deep-sea deposits. Both of these views being untenable, another must be sought.

48. Univ. Geol. Surv. of Kansas, 2: 207-209.
49. Cretaceous Flora, p. 23.

Roaring Spring cliff, north of Terra Cotta, Ellsworth county, Kansas, showing Dakota sandstone. Photo by Jones.

Pulpit rock, Alum creek, Ellsworth county, Kansas,
Photo by Beede, 1900.



Mushroom rock, Alum creek, south of Carneiro, Ellsworth county, Kansas.
Photo by Beede, 1900.

Table rock, in southeast Lincoln county, now destroyed.
Photo by Jones, 1899.

Doctor Lesquereux, nearly thirty years ago, promulgated a theory to account for these beds, which to the mind of the writer is the most reasonable of any yet advanced. It will be given in a somewhat abbreviated form in the language of the noted author. After pointing out the resemblance of the Dakota to certain sandstones of Devonian and Carboniferous ages, Doctor Lesquereux says:

"The origin of these groups of sandstone is the same, to my belief at least. They are beach formations, like those in progress at the present time along the shores of the North Sea, in Holland and Belgium, where the widely extended, muddy shores are formed of a soft substance of the same red color. As I have had opportunity to examine it, it is a mixture of small grains of sand, brought from the sea with the mud deposits, carried by rivers of long course, after traversing flat countries. By slow deposition it constitutes low shores, successively washed by the tides, which of course recede or advance farther in proportion to the slow upheaval or depression of the land. Marine animals, the shells especially, are very rare in a formation of this kind."[50]

Then follows a short discussion of the leaves of the Dakota, from which the conclusion is drawn that the essential types of the vegetation are those of low islands and shores, rather than of hills and dry land. In speaking of the origin of the leaves, he remarks:

". . . The Cretaceous leaves have been derived from trees or groups of trees growing in the vicinity of muddy bottoms, where they have been buried and fossilized. . . . The deposits seem to have been local, dependent upon circumstances. There must have been, necessarily, an arm of the sea, with soft, sandy mud, bordered by the adjoining dry land covered with a forest. The characteristics of the local deposits indicate that the forests were on small islands scattered over the Cretaceous sea."

". . . The formation of the Dakota group is the result of muddy flats whose surface, raised perhaps in hillocks above water limits, and already solid ground, was cut like an immense swamp, here and there interspersed by rare groups of trees and bushes. Of course the main portion of this surface was subject to continuous change in the successive modifications resulting from the heaping and displacement of matter by water, and thus the leaves were distributed either at the same place but at different levels, or at the same level but at different localities."

To this it seems necessary to add that recent investigations in the field but confirm the accuracy of the theory.

PECULIAR FORMS OF STRATIGRAPHY.

While the ordinary characters of Dakota stratigraphy are those described, yet throughout the group there are departures from the normal form that deserve especial notice. These peculiar forms may be confined to special localities, or, as in the case of nodular concretions, may be distributed throughout the entire group. These concretions vary greatly in form, size, and color. Oftentimes they are small and box-shaped, with angular corners and edges, an inch or two across, with a predominating dark-brown color. They break with a conchoidal fracture, exposing cutting edges. The enclosed cavity is usually filled with white or cream-colored clay. More frequently, perhaps, the concretions are spherical or geodic in structure, and when broken form hollow, bowl-shaped vessels. Not infrequently these lie scattered over the surface, forming reservoirs in which rain-water collects. Very often the concretions are solid, varying in size from that of a pea to that of a baseball. These may be found either solitary or cemented into clusters. Sometimes these clusters will be grouped together, resembling a bunch of grapes; or perhaps but two will be joined, something after the manner of a double walnut.

50. Cretaceous Flora, p. 27, *et seq.*

In many places in the heavier ledges the concretionary structures assume gigantic proportions. They are often twisted and crumpled into grotesque and fantastic shapes. These forms are so radically different from anything else in the region that to the common mind they suggest volcanic action, and the geologist is often wearied with explaining to the farmers along the line of outcrops that neither volcanoes nor earthquakes had anything to do with these peculiar forms. Some of these concretions are as much as ten feet in diameter, and consist of a series of dome-shaped layers from one to two inches thick, arranged one within the other. These layers are often in direct contact; or again they may be separated by several inches. Not infrequently the inner layers have disappeared by concentric decomposition, and only the outer shell remains, often forming a cave in which a man may stand upright.

These masses of clay ironstone are often found in the form of streaks or bands throughout the sandstone, usually following the line of stratification. The box-shaped and spherical concretions described above are ordinarily found in the clay banks, but sometimes occur in the sandstone. Doctor Hayden evidently referred to these concretionary bands when he said: "There are also some seams of iron ore, which, when broken with a hammer, gave forth a sound much like that from old pot metal. It is really a pretty fair iron ore, but quite silicious and impure."

The theory of the origin of concretionary structure seems at the present time to be rather indefinite. This article makes no attempt at an explanation of these most interesting phenomena. It is a question that calls for persistent and systematic research; and it is to be hoped that some competent investigator may shortly give it his attention. When this shall be done the Dakota group will supply an abundance of material.

Throughout the Dakota area there are numerous peculiar forms of erosion. Castles, chimneys, towers and forts are some of the popular names with which these marked forms are designated. Pulpit rocks, near Carneiro, and Rock City, southwest of Minneapolis, Kan., are perhaps, the most striking forms. The pulpit rocks are on Alum creek, a mile south of Carneiro, Ellsworth county, Kansas. At this place a ledge of rather hard gray sandstone rests on a much softer ledge. Along the side of the hill the softer ledge naturally weathers away more rapidly. The upper and harder layer is in most places entirely removed, but in a few cases it persists in the form of large, irregular, spheroid masses, bearing not a little resemblance in shape to the large puffball of the prairies. Some of these rock masses are twenty feet in diameter and fifteen feet high. They are usually found lying flat on the ground, but are sometimes tilted or even on edge. In a few cases there is left a pedestal of the underlying soft sandstone, supporting a mass of rock many times its own size. In such case the similarity to a puffball is still more strongly marked. One might almost imagine that the fungus, stalk and all, had simply increased in size until it had reached its present gigantic proportions, and had then been petrified. The largest of these pulpit rocks has a pedestal twelve feet high and not more than six feet across at the top, on which is supported a globular mass of sandstone fifteen feet high and twenty feet in diameter. (See plates IX, X.) The marked stratification of the upper layer gives to the rounded mass a peculiar appearance, not unlike that of jelly-cake. This harder ledge may be seen outcropping on a number of hills in the vicinity; but in no other locality are the marked forms of erosion so conspicuous as at the spot just described.

Rock City, five miles from Minneapolis, Kan., consists of several hundred rock masses very like those at Carneiro, except that here the pedestals are

wanting and the balls rest directly upon the ground. They cover a space of perhaps two acres; and when seen from a distance present the appearance of a military encampment, or even of a city, whence the name. The masses are ordinarily globular, from fifteen to twenty feet in diameter, and have the general appearance of an Eskimo hut. They are often so close together that a person may step from one to the other. In some places are passageways wide enough for a wagon to pass through. All stages of formation and erosion may be seen, from the stage where the top of a boulder is just protruding from a bank, through forms that are only half uncovered, and complete globes, to those that have fallen to pieces and are weathering away. Table rock, in Lincoln county, Kansas, until recently exhibited the same peculiarities of form that are seen in Pulpit rock to-day, but has now fallen down. (See plate XI.) These are all pronounced erosion forms; and as such are of more than usual interest both to the geologist and to the ordinary observer.

In lithological character the hard ledges mentioned above approach a quartzite. There are several such ledges in the Dakota. In eastern Saline and northern McPherson counties, Kansas, quartzite boulders are not infrequent. Doctor Hayden refers to numerous layers from one to four feet thick, of a very compact, massive quartzite, at the Blackbird mission, Nebraska. Doctor Barbour and the writer, in October, 1890, visited a ledge of extremely hard and massive quartzite-like rock five miles northwest of Fairbury, Jefferson county, Nebraska. This ledge is gray in color, and consists of very fine grains of sand cemented with calcium. These ledges all produce an excellent building stone, and will be discussed more in detail under "Economic Phase."

One of the most peculiar forms of Dakota stratigraphy is found in the gravel-beds on the Platte river, at Cedar Creek and Springfield, Neb. At this point the Dakota rests on the unevenly eroded surface of the Carboniferous. The line of contact between the two groups sometimes differs as much as seventy-five feet in elevation in a few hundred yards. In those long-gone Mesozoic times the hills were evidently as high and the hollows as deep as those of the present time. It is in one of the lowest of these hollows that the gravel-bed has been deposited. The best exposure is a mile west of Cedar Creek, at which place the railroad has run a spur along the base of the hill for the purpose of obtaining gravel. The lower twenty feet of the Dakota consists of an extremely hard conglomerate, arranged in layers, which are usually cross-bedded and interspersed between ledges of typical brown sandstone. The conglomerate is composed of hard, water-worn pebbles of quartz, feldspar, granite, etc., varying in size from fine sand to the size of a walnut. These pebbles are cemented together by silicon into a rock which is so hard as to be broken with great difficulty. The form and color is so peculiar as to obtain for it the characteristic name "peanut rock." Above the hard conglomerate at the base of the group is found from twenty to forty feet of loose gravel and sand. It differs from the lower ledge chiefly in the size of the pebbles and the relatively smaller amount of cementing material. The pebbles are rarely larger than pigeons' eggs, and are so loosely cemented together that the material may often be removed with a scraper. The bank shows all gradations from coarse gravel to very fine sand, and is in most places more or less cross-bedded. There are some ledges of typical Dakota sandstone and a few fragments of silicified wood, but no leaf remains have been found.

It is probable that the gravel-beds mark the location of an ancient Dakota river. The lines of cross-bedding usually incline toward the southwest, indicating that the current came from the northeast, which agrees with our ideas of the origin of Dakota deposits. It is a matter of common observation that, while

wood is often fossilized in flowing streams, leaves are almost never preserved under such conditions. In fact, it has almost become a paleobotanical axiom that conditions which preserved leaves did not preserve wood, and *vice versa*. The theory that these deposits represent a river-bed seems strengthened by the fact that several exposures are found in a line extending northeast and southwest on both sides of the Platte, while "peanut rock" is not known in the group outside of the locality just described.

ECONOMIC PHASE.

INTRODUCTION.

The region of Dakota outcrops is by no means the most fertile in the states in which the group is located. The reasons for this fact are several. The country itself is usually too rocky to admit of cultivation, except in the valleys. Again, the soil is often rather light, owing to the presence of so large an amount of sand. The cultivated fields on the slopes wash badly, and in many cases have been permitted to revert to their original condition of grass-covered prairie. As a grazing country it has no superior in the West.

The rocks of the Dakota group, however, furnish a variety of products of economic value. These are distributed throughout the entire region, and are in many places a source of a very considerable income. These products will be discussed in the following order: Building stone, clays, coal, sand and gravel. More than ordinary importance will be attached to these products when it is remembered that in a prairie country, such as is occupied by the Dakota, materials of this character are comparatively rare. In not a few instances the Dakota is the only rock found. In such regions its products are consequently greatly enhanced.

BUILDING STONE.

The sandstone ledges so common in the Dakota are quarried in numerous localities in both Kansas and Nebraska. Nevertheless, in proportion to the amount of available material the Dakota is used to only a limited extent. The reasons for this are several. Of these, but two will be discussed in this connection.

First. As a rule the Dakota sandstone is not desirable building material. Representing all degrees of hardness from the very hard clay ironstone and quartzite-like rock, which is so hard as to turn the edge of the best tools, to the soft sand scarcely cemented together, the stone is either too hard to be dressed or too soft to resist weathering. Another objection is the absence of even fracture in the stone. Most of the ledges are cross-bedded, and, in quarrying, it is almost impossible to obtain anything like symmetrical blocks, the bedding plane being at all sorts of angles except right angles. Again, the color of the stone is often urged as an objection to its use for building purposes. The amount of iron in the various ledges even in the same quarry is rarely constant, and the irregular streaks and blotches of brown, red and yellow in the walls of buildings present anything but an artistic effect.

Second. With exception of the southern Kansas region and the Missouri locality, there is scarcely a place in the two states where either the Carboniferous, Permian, or Benton limestones do not outcrop within a few miles. Usually it is but a short distance to quarries of one or both of these formations, yielding excellent building stone. As the limestone is more easily worked, is more durable, and presents a more artistic appearance than the sandstone, it is often hauled within Dakota areas and even past quarries of Dakota sandstone. This may be observed in Cloud and Washington counties, Kansas, and Jefferson county, Nebraska.

Notwithstanding these facts, there are hundreds of buildings along the line of outcrops constructed of the sandstone. The group might be traced from Oklahoma to South Dakota by observing buildings alone. Stone fences, corrals, and foundations throughout certain sections are constructed almost exclusively of this material. But the use of the sandstone is not confined to the lesser structures. Dwellings, railroad depots, business blocks and schoolhouses are built of the Dakota. Some of the towns in which may be seen buildings of this stone are: Larned, Pawnee Rock, Great Bend, Ellinwood, Ellsworth, Kanopolis, Brookville, Glasco, Concordia, and Washington, Kan.; and Fairbury, Endicott, Beatrice, Lincoln, Ashland, Louisville, Tekamah, Homer, and Dakota City, Neb. If limestones were not so plentiful the number would be greatly increased. It is a noticeable fact that this sandstone is rarely shipped by rail.

There are, however, several localities in the group where valuable building stone may be obtained. The best of this stone is from the quartzite ledges mentioned under "Stratigraphy." So far as known, there are three outcrops of the quartzite, in widely separated localities in the Dakota. The quartzite-like boulders in the vicinity of Salina, Kan., and thence fifteen to twenty miles southeast, mentioned by Doctor Beede,[51] will furnish an almost inexhaustible supply of the best of building material. The principal objection to its use is its extreme hardness, which only argues in its favor. The last time the writer visited Salina (in 1898), the quartzite near the old mill in the southeast part of the city was being removed for building purposes.

A ledge on Whisky run, five miles northwest of Fairbury, Jefferson county, Nebraska, is composed of very hard, gray, quartzite-like rock. The exposures occur along the sides of a ravine, and where seen were some four feet thick. The stone contains numerous finely preserved dicotyledons and wood fibers. There are also some pockets of iron pyrites, but scarcely enough to detract from the value of the material as a building stone. The rock from this ledge has been used in the construction of several farm buildings; but it is in bad repute among local stone-masons on account of its extreme hardness. It is the best building stone known in the state, and when developed promises to become an important economic factor. The hard ledge near Blackbird mission, on the Omaha reservation, mentioned by Doctor Hayden, is very like the Whisky run stone, but is not quite so hard. The old Presbyterian mission building, a large four-story structure, constructed of this stone fifty years ago, seems as solid to-day as when it was completed, and bids fair to stand for centuries. The ledges from which the rock was obtained are from one to four feet thick. Several other ledges along the bluffs back of Dakota City furnish rock of about the same character.

There is no reason why material from the quarries just described should not take the place of Wisconsin and Colorado stone in eastern Kansas and Nebraska. In appearance, durability, and general utility it is the equal of any that is being shipped into these states; and the supply is practically inexhaustible. Nothing is needed but the development of the quarries.

CLAYS.

Clays and shales occupy the greater part of the Dakota group. The term Dakota "sandstone," by which the group is known, is clearly a misnomer. The sandstones, being harder, resist denudation and by their uneven weathering give tone to the erosion forms throughout the Dakota area. It is rare that the clays and shales are to be observed when passing through the region of outcrops; while the sandstone ledges are everywhere conspicuous. The ledges of shale

51. Univ. Geol. Surv. of Kansas, 2: 291.

usually weather into gentle slopes, which are almost uniformly grass covered. It is only along the steep banks of streams or in artificial exposures such as railroad cuts that typical exposures of the clay may be seen. It is the opinion of the writer, after having studied the group in thousands of exposures, in four states, that at least two-thirds of the rock consist of clays and shales.

The character of this material is by no means constant. From a very arenaceous shale, with the prevailing yellowish-brown color, it grades through varieties less and less sandy; until finally in not a few places may be found dark-blue and almost black papyraceous shales and clays, resembling in lithological appearance those of the marine Kiowa. Between these two extremes of color are endless varieties and shades, with red, pink, yellow, cream and white predominating. Oftentimes all these colors may be seen in the same clay bank. Not infrequently thin, lenticular ledges of sandstone or concretions of various shapes and sizes are found embedded in the shale. These concretions, being normally of a dark reddish-brown color, and breaking with a conchoidal fracture, often render the slopes conspicuously brown. This clay is probably designed to become the most valuable economic product of the Dakota. The large and varied amount of iron contained in it, which causes the differentiation of colors, constitutes it a very superior brick and tile clay. The pottery products are also exceptionally fine.

In a number of localities brick-works which obtain their material from Dakota clay banks are in operation; and when experience shall have demonstrated the superiority of the products these plants can but increase. The sandstone of the Dakota, as has been shown, can never have more than a local value. Coal is limited in quantity and poor in quality, sand is found elsewhere, and gravel is not plentiful in this formation. The clay, on the other hand, being inexhaustible and of excellent quality, will be wrought more and more and the products shipped to distant localities.

The Yankee Hill Brick and Paving Company operates a plant three miles southwest of Lincoln, Neb., which may serve as a typical representative of the brick-works of the Dakota area. The clay is in this case obtained from a horizon a little above the middle of the group, probably about 100 feet below the Benton. Something like three acres are included in the bank, although the material in sight covers over 100 acres. Above the Dakota at this locality are some twenty feet of glacial drift and loess. From this material a certain kind of brick is manufactured. The following section, taken in a typical part of the bank, will indicate the sequence of the beds:

No. 6.	Soil	5 feet.
No. 5.	Loess	10 "
No. 4.	Drift boulders and pebbles	2 "
No. 3.	Yellowish, sandy clay, known as "bastard fire-clay"	3 "
No. 2.	Red, pink and white mottled clay	15 "
No. 1.	Sleek, blue-gray clay shale	10 "

A hundred yards from the place where this section was taken the red and white mottled clay, *No. 2*, occupies nearly the entire thickness of the exposures; again, the yellowish fire-clay is more pronounced; while a quarter of a mile away, just over a small hill to the west and approximately on the same level, the clays have given place almost entirely to coarse, soft sandstone.

Experience has proven that a judicious mixing of the clays from the various horizons produces several different qualities of brick. The ordinary building brick is obtained by using two parts of the red mottled clay from No. 2 and one part of the loess, or No. 5; *Nos.* 1 and 2 in equal quantities make paving brick;

and the yellow clay from No. 3, treated by the dry process, makes a buff or cream-colored pressed brick superior to the Milwaukee product. The mottled clay when used alone produces a red and white mottled brick much in demand for ornamental fronts, and the clay from the same beds is used by the Lincoln pottery for the manufacture of its products.

Along the bluffs of the Big Sioux river, near Sioux City, Iowa, the clay between the Dakota and the Benton is excavated from a bank some sixty feet in thickness. In general, the clay at this locality is bluish drab or gray, and reminds one of the lower stratum at Yankee hill. Several companies are engaged in the manufacture of brick and tile at this place. At Sergeant's bluff, Iowa, nine miles below Sioux City, there are two plants engaged in the manufacture of brick. The material is obtained from a bank a quarter of a mile long, and in general appearance resembles the Sioux City clay. On the hill north of the Platte river, opposite Louisville, is a bank from which the clay is shipped to Omaha, and there made into brick and tile. At Beatrice, the material from the Dakota beds have been extensively manufactured into brick, as also have the clays obtained near Endicott. An enumeration of the localities containing available brick clay would simply be a catalogue of outcrops throughout the two states. There is scarcely a square mile of the Dakota that could not furnish sufficient clay to make brick to build a city.

COAL.

The coal of the Dakota group is inferior in quality and limited in amount. It is a lignite, or, as the popular phrase has it, "brown coal." This lignite is found throughout the group, from Oklahoma to South Dakota, ranging from the Permian or Comanche to the Benton. Knowing what we do of the conditions under which the deposits were made, we should be surprised not to find evidences of masses of decayed vegetation. In general, the conditions differed not materially from those that obtained in the Carboniferous age. The trunks and branches of trees, which in this case were dicotyledons instead of acrogens, blown down by the wind or swept away by the current, lodged in sheltered coves and were covered with sediment. These drift accumulations have since been converted into the lignite which is found today. The conditions have not been favorable to the production of harder coals, except in isolated and very limited areas.

Half a mile south of Bond's mill, Washington county, Kansas, several thin seams of lignite are found within a few feet of the underlying Permian. At the High banks, near Decatur, Neb., similar seams appear at the water's edge, probably about the middle of the group. In describing a bed of lignite near the mouth of Iowa creek, west of Sioux City, Doctor Hayden says that it is in the Benton, or at least in the transition between the Dakota and Benton, and that it is local or restricted in its geographical extent, and is the result of the accumulation of drift in the Cretaceous sea.

It is in the Smoky-Blue area in north-central Kansas, however, that the beds attain sufficient importance to be of commercial value. Even here they vary much in thickness. Some beds are two feet thick. Usually they are much thinner. Not infrequently the lignite is altogether wanting. It is found interspersed between beds of sandstone and shale, with often beds of carbonaceous shale near by. The horizon is usually from 60 to 100 feet below the Benton. The coal is most frequently obtained by stripping or removing the ledge near the surface. Occasionally shafts are sunk from the surface to the level of the lignite. These shafts are sometimes as much as seventy-five feet deep. Although the coal is of such poor quality, the price at the mouth of the shaft is usually as high as that of good coal in regions where the latter is plentiful.

Lignite is mined and used for fuel in Barton, Cloud, Ellsworth, Jewell, Lincoln, Mitchell, Republic, and Russell counties, Kansas. Some of the principal mines are at Wilson and Ben's Ranch, Ellsworth county; Coal cañon, Russell county; Elkhorn creek and Rattlesnake creek, Lincoln county; and Rock creek, Mitchell county. The supply is quite considerable and promises to meet the local demand for a number of years. That it will ever do more than this is scarcely to be expected.

SAND AND GRAVEL.

Like clay, sand is a constituent part of the Dakota. The supply is inexhaustible and the quality usually suitable for building purposes. As in the case of stone, however, there is often better material at hand, and the Dakota sand is not in great demand. As stated above, the region of Dakota outcrops is cut nearly at right angles by a number of streams flowing southeast. These streams ordinarily take their rise in the Tertiary, or at least flow across these formations, and for the most part have numerous low banks and sand-bars. The supply of sand for the larger towns, which are usually situated in the valleys, is obtained chiefly from these streams. In the Glacial regions the sand for building purposes is obtained from pockets in the drift. The Dakota sand is rarely so loosely cemented that it can be removed without the use of the pick; more often powder must be used to loosen the rock, which is afterward pulverized with the sledge. The drift sand, on the contrary, may usually be obtained with the shovel. An example may be cited at Lincoln, Neb., where the building sand is obtained from numerous drift pockets near the city, although there is in the vicinity plenty of Dakota sand, which would be used were the drift sand not more easily obtainable.

In not a few localities, however, the Dakota sand is utilized for building purposes. One of these is at Bennett, Neb., referred to above. A small outlier of the Dakota forms a cliff thirty feet high, surmounted by drift boulders. The sand is taken from the face of the cliff and utilized for general building purposes. A similar sand-bank is found at Tekamah, Neb., from which the sand is in places removed with the shovel, while only a few feet away it is so hard as to require blasting. The material from the Tekamah ledge makes a superior brick sand. In the vicinity of Beatrice, Neb., there are a number of Dakota sand-banks. One west of the Blue river furnishes 400 wagon-loads a year. Besides being used for building purposes, it has been utilized as molding sand by the Dempster Windmill Company.

Gravel is not common in the Dakota. The few localities in which it has been found are generally located in the hollows of the old Carboniferous floor upon which the younger Dakota has been deposited. These localities are invariably found near the eastern edge of the group. The most typical examples are seen on the Platte river, in eastern Nebraska, and have been discussed under "Stratigraphy."

The Cedar creek gravel-bed, which is, perhaps, the best known, was seemingly deposited in the channel of an ancient Dakota river. The material, which has been extensively excavated, is used by the Burlington & Missouri River railroad for ballast, riprap, fills, and foundations. The Missouri Pacific gravel-beds near Springfield, Neb., are very like those at Cedar creek. The supply in these localities is very considerable and will last for many years.

WATER-SUPPLY.

INTRODUCTION.

The Dakota is distinctly a water-bearing formation. The porous sandstone is capable of storing great quantities of water, while at the same time it offers very little resistance to its flow. Even the shales are in most places more or less

arenaceous, and usually permit the water to percolate throughout their entire thickness.

Springs are abundant in all parts of the group. It would scarcely be an exaggeration to state that there is an average of one spring for each square mile of Dakota territory from Oklahoma to Minnesota. Some of these are mere seepage springs, which cease their flow during dry weather, while others have a perennial flow. The springs of the group may be divided into two classes: fresh-water springs, and salt springs and marshes. The former occur indiscriminately in all parts of the formation, while the latter are ordinarily confined to the upper layers.

Something of the nature of the water in the various localities may be learned by noticing the names of the smaller streams throughout the regions of outcrops. In Ottawa, Republic and Washington counties, Kansas, and in Lancaster county, Nebraska, there are streams which have the characteristic name of Salt creek, and in Cloud county, Kansas, there is a Salt Marsh creek. In Ellsworth county, Kansas, Alum creek and Oxide creek bear testimony to the character of the water contained in them. All of these creeks take their rise in the region of the upper layers of the Dakota, usually near the Salt Marsh horizon of Logan. Saline river owes its name to the fact that it receives much of the drainage from these salt creeks. On the other hand, such names as Spring creek and Clear creek, which are by no means uncommon in the region, indicate that the stream is fed by fresh-water springs, usually from the lower beds.

ORIGIN OF DAKOTA WATER.

Three theories have been advanced to account for the water-supply of the Dakota. They may be designated as the artesian theory, the sheet-water theory, and the local-rainfall theory. It is proposed to outline briefly these three theories, and to draw from them such conclusions as seem warranted by facts.

Perhaps the chief exponent of the artesian theory is Mr. N. H. Darton, of the United States Geological Survey. Mr. Darton has spent a number of seasons in the field, in the plains and Rocky Mountain regions, and is entitled to speak with authority on the subject. In his excellent paper on the "Geology and Water supply of Western Nebraska,"[52] he discusses the question of deep-seated waters, and touches on the subject of artesian water in the Dakota. It should be remembered that the Dakota sandstone passes under the more recent Cretaceous groups to the west. These later groups attain their maximum thickness in western Kansas and Nebraska, where the Dakota is probably more than 2000 feet beneath the surface. The greater part of this thickness is composed of Pierre shale, which is impervious to water. The sandstone of the Dakota, continuing westward, outcrops along the eastern slope of the Rockies and Black hills at an elevation of from 3000 to 6000 feet. The water, passing into the porous sandstone at these elevations, flows eastward beneath the Pierre shales, and has considerable pressure and head at a great distance to the east. In eastern South Dakota, the artesian wells, which yield a large amount of water, obtain their supply from the Dakota sandstone. The wells and springs of eastern Nebraska are thought to derive their supply from the same source. In this region, however, the pressure and head, which gradually decrease as the formation approaches the surface, have nearly disappeared. There are several springs in the region which are known locally as artesian springs.

"Sheet water" is a term which, in the states of the plains, is used rather loosely to indicate a steady and constant supply of well-water. The term is

52. Nineteenth Ann. Rept. U. S. Geol. Surv., pt. 4, pp. 719-785.

popular rather than scientific, and in this connection will be so used. In the Tertiary deposits of western Kansas, or the glacial material of eastern Nebraska, the so-called sheet water is usually found at the base of these surface formations, near the top of the underlying strata. The Cenozoic deposits, being for the most part composed of more or less porous clay, sand, and gravel, readily absorb large quantities of water, which gradually settles to the base of the formation till it finds a lodgment in a sand-and-gravel bed above an impervious stratum, the latter most often occurring at the line of unconformity with the subjacent formation. This, of course, means that the wells, in order to strike sheet water, must in most cases penetrate the entire thickness of the surface deposit.

Now it is very evident that the Dakota sandstone does not form a good floor for holding water. For this reason, if the subjacent strata be Dakota, the water, instead of remaining at the bottom of the Tertiary or Glacial, will readily enter the sandstone, which is ordinarily even more porous than the overlying rocks. It is to this sheet water, then, that many geologists look for the greater part of the water of the Dakota group.

There is little doubt that a considerable portion of the water-supply of the Dakota may be accounted for by the theories just discussed. It is difficult, not to say impossible, however, to believe that all the water in the group comes from either the Rocky Mountain region or from the sheet water of the Tertiary and Glacial. Mr. Logan recognized this fact and discussed the question at some length. Among other things he says: "It is not impossible that the source of a large part of the water is much nearer at hand than even the Tertiary formation. The Dakota sandstone is capable of storing a great quantity of water and of retaining it for a long time."[32]

Two examples are given, illustrated by figures, showing that a comparatively small area of sandstone is capable of storing a sufficient quantity of water to supply a perennial spring. The most conspicuous example given by Mr. Logan is that of Terra Cotta mound, in the eastern part of Ellsworth county, Kansas. This mound is a solitary butte, consisting of 100 or more feet of shale and clay capped with a forty-foot ledge of sandstone. Although the sandstone is but a few acres in extent, a spring which flows from its base near the top of the shale is so strong that the water is carried through a pipe to a tank in a farmyard at the foot of the mound, where it furnishes sufficient stock water for the farm. It is evident that the water that supplies this spring either comes from the rainfall on the sandstone or else it is drawn up through the shale. Whichever solution is adopted the problem is not an easy one. It appears vastly improbable that capillarity or any other known physical force can draw this amount of water through such a thickness of shale; while, on the other hand, it would seem that the rainfall on a rocky point of not to exceed three acres, in a region where the annual rainfall is but twenty-six inches, is not sufficient to supply a never-failing spring.

One point on which the writer has attempted to inform himself, but with indifferent success, is that of the relative flow of springs in wet and dry seasons. Inquiries have been made concerning hundreds of springs with regard to the steadiness of flow. Many persons will assert that certain springs show no difference in amount from year to year, while others with equal opportunities for observation will declare that a marked difference in flow may be observed in wet and dry seasons. As far as my observation goes, some of the springs appear to

32. Univ. Geol. Surv. of Kansas, 2: 213.

have a steady flow, while others, perhaps the majority, are more or less intermittent.

There are, however, in the Dakota a number of springs, which can be accounted for by neither the sheet-water nor the artesian theories. They are usually located along the eastern margin of the outcrops, where the post-Cretaceous erosion has isolated buttes and ridges from the main body. A striking example may be found some fifteen miles southeast of Salina, Kan., where a narrow Permian ridge, half a mile wide and several miles long, is capped with fifty feet or more of the Dakota sandstone. At the base of the sandstone, along the east side of the hill, are a number of springs which flow all the year round. The water is evidently derived from the local rainfall on the Dakota ridge. Perhaps the best example of springs of this character may be found at Bond's mill, six miles west of Hanover, Kan. South of Mill creek, at this place, is a steep bluff 200 feet high, of which the upper part consists of Dakota. From the top of this bluff the country slopes gradually to the south, being more or less cut up by numerous deep ravines flowing to the east and west. At a distance of four miles south from the top of the bluff a gap has been worn down into the underlying Permian, completely isolating this area of Dakota, consisting of perhaps ten square miles, from the main body. Some of the finest springs in the Dakota region are to be found in this locality. Mr. Richard Bond, who located in the vicinity in 1858, assured the writer that the water from the spring which supplied his house showed no variation in the amount of flow in wet or dry seasons. The water must of necessity come from the local rainfall.

These facts appear to indicate that we may well look to all three sources discussed in this connection for the water-supply of the Dakota. While it is probable that a large amount of water comes from the mountains, and perhaps a still greater amount is sheet water, it can scarcely be doubted that in all localities the local rainfall helps to swell the volume, and is in many places the only source of supply.

FRESH-WATER SPRINGS.

The term "fresh-water springs" is used to include all the springs in the Dakota in which the water is not more or less salty. While in this connection it has no particular reference to what is usually known as soft water, still it is a notable fact that the water of the Dakota is unusually free from the various compounds of calcium that constitute hard water. Not infrequently the water has a taste not unlike that of rain-water. This is particularly true when the stratum from which it flows contains no clay.

It will be obviously impossible to mention but a very small per cent. of the thousands of springs which have been noticed in Kansas and Nebraska. At best, only a few, and those the most typical, may be referred to. In Kiowa county, Kansas, near the head of the Medicine river, in the locality west of Belvidere mentioned as yielding dicotyledonous leaves, there are numerous springs in a ledge of sandstone near the base of the Dakota. These are found chiefly on Spring creek and Little Rocky cañon, some ten miles south of Greensburg. In Clark county the best springs on Hackberry, Bear and Chapman creeks are from the Dakota. Near the base of the bluff washed by the Arkansas river, three miles east of Ford City, a spring issues so close to the water that it may only be seen when the river is low.

The area of the Dakota in northern Kansas is famous for both fresh and salt springs. In southern Ellsworth county, the creeks—Thompson, Oxide, Bluff, and others, which flow north into the Smoky Hill river—are fed by springs which issue from near the middle of the group; those at Burton's and Sher-

man's ranches being especially noticeable. At the noted cave section in eastern Ellsworth county there is a fine spring, the delight of picnic parties, for which the place is a famous resort. On the vertical cliff of sandstone above the spring may be seen Indian pictographs, which would seem to indicate that the aborigines were in the habit of frequenting the place. Unfortunately these hieroglyphics, which have so far escaped the ravages of time, are now being destroyed by visitors carving their names over the pictographs. This vandalism is the more to be deplored, because of the fact that the picture-writing, once destroyed, can never be replaced. It is but a few years at most until these records of a forgotten people shall have been obliterated. In Washington county, Kansas, where the Dakota has typical development, springs are abundant. Southwest of Washington, the county-seat, there are several that have a strong and persistent flow. Near Hollenberg, in the northern part of the county, springs issue near the base of the sandstone and supply the small streams which flow into the Blue river. Those on the farm of Jonathan Alden are worthy of special mention. Near Bond's mill, referred to above, along the bluffs south of Mill creek, there are dozens of springs that issue from the sandstone ledge near the base of the Dakota, immediately above the Permian. The water is, in some instances, piped for half a mile or more to farmhouses along the base of the bluff.

The largest area of Dakota in Nebraska, near Endicott and Fairbury, contains hundreds of springs. They flow into creeks which are tributary to the Blue. Those on the farm of Edward Case, a mile east of Endicott, are known throughout the country; while others on Whisky run, northwest of Fairbury, are nearly as strong. One of the most typical springs in the state is on the Robinson farm, a few miles south of Beatrice, where the water is carried in a pipe for half a mile, under a ravine and into a tank, where it furnishes an abundant supply for several hundred cattle. In the valley of Salt creek springs are abundant. On Haines branch, especially, salt- and fresh-water springs issue all along the bank for several miles. On the Platte river, from Plattsmouth to Ashland, of the hundreds of springs but one need be referred to. It is the one at the state fish hatchery, a short distance above South Bend. The spring issues from the sandstone in a deep ravine, and furnishes water for some thirty reservoirs in which the fish are bred.

From Blair to Tekamah, along the bluffs of the Missouri river, there is a continuous row of springs. Above Tekamah these become more frequent, and along the "bench road" between that city and Tekamah, a distance of sixteen miles, there are an equal number of strong springs, besides many smaller ones. In the following enumeration, beginning at Tekamah, the name given is either that of the owner of the farm upon which the spring is located, or else the local name by which the spring is popularly known: Shafer's, John Latta's, Rath's, Davis's, C. H. Johnson's, Marrow's, J. Laughlin's, Marsh spring, Stanton's, Golden spring, Landig's, Tippery's, H. Bussie's, A. White's, Decatur spring. Of these, Tippery's spring is known as an artesian spring, and is said to throw water to the height of sixteen feet. Golden spring has the strongest flow of any spring in the Dakota group, so far as observed. It has long been a famous stopping-place for freighters. Professor Capellini, in describing his trip from Tekamah to Sioux City, in 1863, gives an account of the spring, of which the following is a *free* translation:

"A spring of water, fresh and crystalline, is located half way between Tekamah and Decatur; on account of the color of the rock over which it flows it has received the name Golden spring (Source d'or). Some small shrubs surround it and give to the place a very picturesque aspect, and *Marchantia polymorpha*

growing along the sand covers that part of the rock over which the water runs in little rills."[54]

Springs issue along the high banks above Decatur, and also near the mouth of Blackbird creek. At the old mission building, two miles north of this creek, there is a spring, famous long before the arrival of white men. At Homer, along the bluffs north and south of the city, there are some of the strongest springs known in the formation, and they continue past Ponca and as far up the river as the Dakota is found.

SALT SPRINGS AND MARSHES.

While the fresh-water springs of the Dakota are found in all parts of the group, the salt-springs, on the contrary, are ordinarily confined to the upper beds. Mr. Logan locates a salt-marsh horizon above the lignite horizon in his upper group, and describes it as follows: "Resting upon the lignite is a bed of shales which are, in the majority of instances, highly saliferous in character. They vary in thickness from ten to fifteen feet. By the disintegration of these shales, salt-marshes have been formed along the exposures of the upper Dakota horizons."[55]

There are a dozen or more of these marshes in north-central Kansas, located in Lincoln, Mitchell, Cloud, Republic, and Jewell counties. In size they vary from a few square rods to several square miles in area. One in Cloud county is seven miles long, and, in places, a mile wide. They are usually found along the basin of one of the numerous creeks in the region, and are at nearly the same geological level—from 50 to 100 feet below the base of the overlying Benton. The marshes are flat and are covered with an incrustation of salt, sometimes a quarter of an inch thick. The water comes from numerous small seepage springs along the margin or on the bottom. The soil is permeated with this salty water, as may be demonstrated by digging a hole in the bank. This soon fills with salt-water which shows a density of from ten to twenty degrees on the salometer.

A description of one of these marshes will be good for a large number of them, as they are very similar in formation and appearance. The following, which is excerpted from a description made by Prof. B. F. Mudge in 1864, will, with a few minor modifications, answer for any one of a dozen marshes to-day. The marsh described is known as the Tuthill marsh, and is located in the southern part of Republic county, Kansas:

"The valley here is wide, gradually rising to the high prairies so common in that part of the state. The marsh covers nearly 1000 acres, more or less impregnated with saline matter. About one-third is entirely void of vegetation, which the brine will not allow to grow. It is perfectly level, and when first visited was as white as a wintry snow field, with a crust of crystallized salt. The marsh is of recent alluvial formation, composed of sand and loam from twenty to thirty feet in thickness, brought down by the wash from the high prairies, which gradually rise from three sides. The incrustation of salt is frequently three-eighths of an inch thick. The brine exists in nearly equal quantities and strength in all parts of the marsh, and can be obtained by boring a few feet. No definite salt-spring shows itself on the surface, but the supply must come from numerous points below."

The chief difference between this description and one made to-day would be in the size of the marsh. The increased amount of alluvium incident upon the cultivation of the adjacent region has so encroached upon the marsh as to materially lessen its area. Nevertheless, several hundred acres are still sufficiently saline to be without vegetation. Wells bored on land above the common level furnish brine which flows from the top of the well out over the marsh. On Salt

54. Memoires de la Societe Helvetique des Sci. Nat., vol. XXII, No. 1, p. 5.
55. Univ. Geol. Surv. of Kansas, 2 : 209.

creek, in southern Mitchell county, there is a large marsh that formerly contained 3000 acres. In the same region are some springs of salt-water which issue from beds of sandstone, evidently the salt-marsh horizon, which outcrops fifteen feet or more above the level of the creek. Great Spirit spring, near Cawker City, owes its saline properties to the fact that its waters are derived from this horizon.

The salt-marshes at Lincoln, Neb., are very similar to those in northern Kansas. They are located in the valley of Salt creek, near the western outskirts of the city of Lincoln. Several branches of Salt creek converge near by, forming a broad and nearly level bottom, containing several thousand acres. Over this bottom the salt flats or marshes are scattered for several miles up and down the creek. The small streams which converge near Lincoln all contain fresh water except one. Haines branch, which flows from the southwest, contains along its lower course hundreds of salt-springs, not dissimilar to those described from Mitchell county, Kansas, except that they issue from mud banks near the water, instead of from the sandstone at a higher level. This may be accounted for by the fact that in the vicinity of Lincoln post-Cretaceous erosion has removed the sandstone.

In general appearance these marshes are so similar to those in Kansas that, on casual examination, no marked difference can be observed; both have the same flat surface, salty incrustations, and seepage springs near the margin and on the bottom. The strength of brine varies little, and in early days salt was obtained for commercial purposes from either locality. Both occupy the same general horizon, from 50 to 100 feet below the Benton, and the character of the rock from which the salt-springs take their rise is practically the same. Near Lincoln, as in Kansas, many of the wells in the Dakota yield salt-water. An example may be cited at the Yankee Hill brick-works, southwest of Lincoln.

Doctor Hayden considered it probable that the salt-water of these marshes came from the Carboniferous shales, which in this vicinity are found at a depth of some 270 feet. The same author, however, considered that the Kansas marshes derived their supply from the same horizons. Later geologists are divided on the question, some contending for the Carboniferous, others for the Dakota age of the salt. One fact that gives much credence to the position of those who look to the Carboniferous for the source of supply is that the shales of this age immediately below the Dakota are highly saliferous and the water contained in them has a strong artesian flow. This fact, together with another condition which seems fairly well authenticated, viz.: that the entire thickness of the Dakota in the vicinity consists of porous sandstones, with scarcely a trace of clay or shale, has been sufficient to establish the theory of Carboniferous origin. Other investigators have pointed out the similarity of these marshes in general appearance and geological position to those less than 100 miles away, in which the salt comes from undoubted Dakota horizons, and have drawn the inference that the salt-marshes at Lincoln and in Kansas must be similarly accounted for.

To the writer it appears probable that one who had studied the conditions in the vicinity of Lincoln alone would be most likely to assign the origin of the salt to the Carboniferous. On the other hand, the geologist who had previously observed the conditions in other parts of the Dakota area, particularly in northern Kansas, would not be wrong in considering the saliferous shales of the upper part of this group as the true source of the salt in the Lincoln salt-marshes.

WELLS.

It is natural to suppose that a formation containing so many springs as does the Dakota would also furnish good well-water. This is almost universally true.

As has been remarked, the Dakota is the most important water-bearing bed of the plains, both on account of the quality and quantity of the water. Whatever theory we may adopt to account for the origin of the water, its presence, abundance, and purity are axiomatic. The amount of well-water that is utilized from the Dakota is probably greater than that of the spring-water. Wells begun in this formation usually find water in abundance at a depth of from ten to forty feet. In the overlying strata the depth to water depends on the thickness of these deposits, the flow being encountered at the line of unconformity, or, if the Dakota, at that particular spot, consist of sandstone, at a short distance below that line. The probability of water being found in the Dakota is so great that, in order to estimate the depth of a well in any locality underlaid by this group, it is only necessary to know the thickness of the overlying deposits. Advantage is taken of this fact in preparing water maps of the various regions. One of the best of these is by N. H. Darton,[56] in which the "depths to Dakota sandstone, which usually yields abundant water-supplies" is graphically represented in colors. Such a map might well be prepared of the entire line of Dakota outcrops and would be of extreme economic as well as scientific value.

As in the case of springs, the wells of the Dakota may be divided into fresh- and salt-water wells. The former so universally predominate, however, as to be understood, unless the others are specifically mentioned. Salt-wells in the Dakota are ordinarily found only in the vicinity of salt-springs and marshes, particularly near Lincoln, Neb., and in north-central Kansas. The water in few of these wells is sufficiently saline to prevent its use, although in a few cases this phenomenon has been recorded. The water-supply of but one of the several artesian basins in Nebraska can with certainty be referred to the Dakota. This is the northeastern basin, in Knox, Cedar and Dixon counties. This region is in reality a continuation of the James and Missouri river artesian basin of South Dakota. The wells in this part of the state find artesian water at a depth of from 300 to 600 feet. The deep artesian wells at Lincoln and Beatrice pass through the Dakota and find their supply in the Carboniferous, at a depth of from 300 to 2000 feet.

One rather interesting fact connected with Dakota wells should, perhaps, be noticed here. It often happens that a farmer whose buildings chance to be situated in a Permian valley near a Dakota hill fails to obtain a sufficient supply of water by digging. Or it may be that the water which he finds is so strongly impregnated with gypsum or other salts which permeate the upper beds of the Permian that it is not fit for use. Not infrequently, after having sunk several wells in the vain hope of obtaining a sufficient amount of good water in the valley, in despair he puts down a well on the top of the hill, in the Dakota sandstone. In such a case he often surprises himself and his neighbors by obtaining an abundant supply of the best of water. Instances of this kind are often pointed out to the itinerant geologist as freaks of nature. The reasons for the phenomenon are obvious.

ECONOMIC VALUE OF WATER.

The region of Dakota outcrops is distinctively a grazing country. Except in the valleys of the larger streams, or on the uplands where the sandstone is covered by later deposits, the greater part of the area is devoted to cattle raising. The sandstone hills produce the most nutritious grasses in the greatest profusion. Thousands of cattle are annually shipped to these ranges from the west, fattened during the summer, and in the fall sent to eastern markets. Some of

56. Water Sup. and Irriga. Papers, U. S. Geol. Surv., No. 12, pl. XVII.

the largest ranches in the two states are in this region. As examples may be cited the Fullington ranch, in Kiowa county, Kansas, which extends for fifteen miles along the Medicine river, or the Sherman ranch, in Ellsworth county, which contains 65,000 acres.

In most places the question of stock water is of paramount importance to the ranchman. It often occurs that cattle raising in a certain locality is not profitable simply on account of the scarcity of water. There is a saying on the plains: "The man that controls the water controls the country." This problem, so vexing in many regions, solves itself in the Dakota areas. The great abundance of water from the numerous springs is usually adequate for all purposes. Very often it is not necessary to give the matter the least attention. The water from several springs unites to form a creek, to which the cattle resort. But if running water is not sufficiently plentiful, the ranchman lays a pipe from a spring on the hillside to a tank. Hundreds of these tanks may be noticed in the pastures of the two states. In not a few instances the water from a good spring will be carried to the house, through the kitchen, through the milk-house, and finally to a tank in the barn-yard, supplying sufficient water for all purposes. The farmer's wife has the advantage over the city woman of knowing that the water she uses is pure.

In former years the salt-marshes of Kansas and Nebraska were a source of revenue to hundreds of persons annually. It is stated that at one time there were several hundred "squatters" located on the salt-basin area near Lincoln, all engaged in evaporating brine. Salt for local purposes was procured in Kansas by dissolving the salt incrustations which covered the marsh, in order to allow the impurities to settle, and afterward reevaporating the brine. The discovery of the magnificent salt beds in the middle Permian of central Kansas has put an end to these cruder methods of production, and it is very improbable that they will ever be renewed.

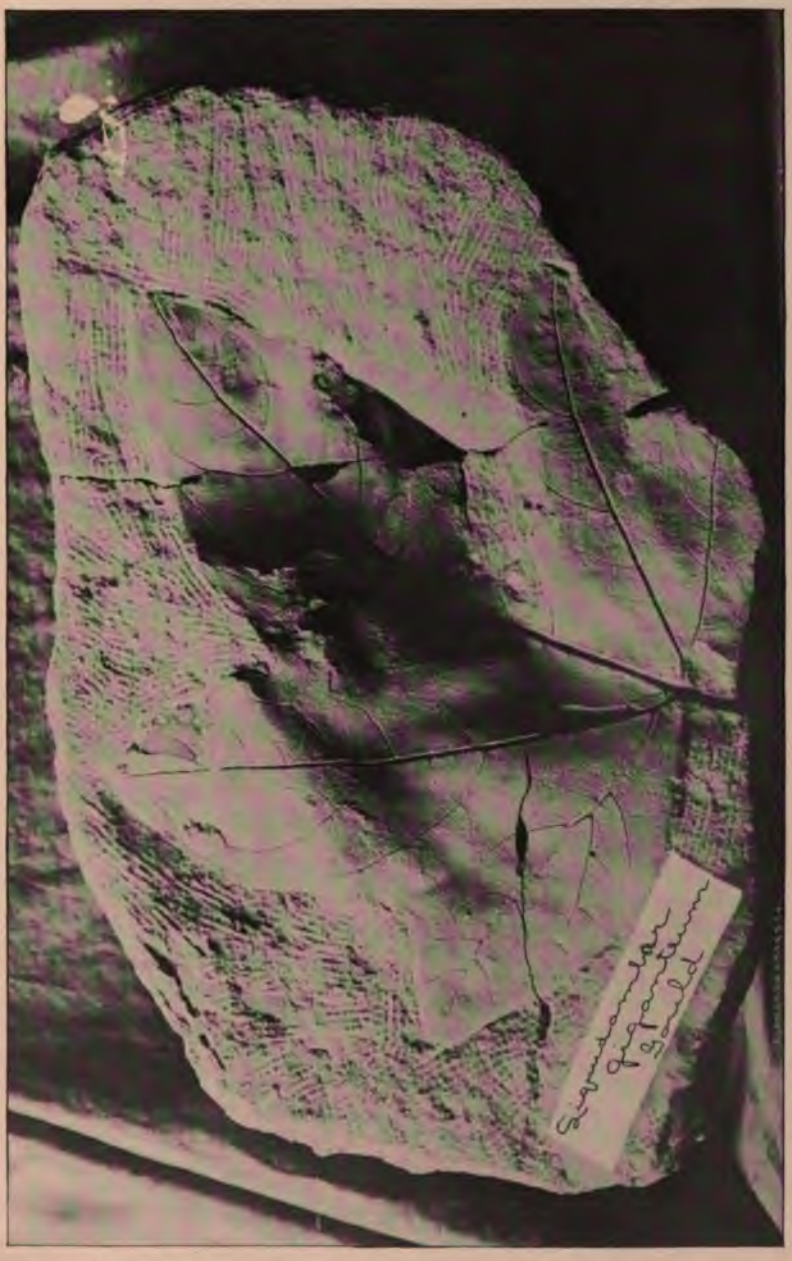
The chief economic value of the Dakota water, however, lies not in the salt-water of its marshes. The thousands of springs, and tens of thousands of wells, in the area of the outcrops of this group witness daily to the importance of water as an economic factor. In such states as those of the plains, where agriculture is and always will be the chief industry, the question of water-supply is paramount; and the Dakota, being the great water holder of the plains, can scarcely fail of recognition in the various problems that are to be worked out concerning the ultimate water-supply of these states.

PALEONTOLOGY.

PLANTS.

While invertebrates are rare, and vertebrates are almost wanting, in the Dakota group, fossil plants are almost universally present. So common are they that their presence usually excites little curiosity among the farmers and ranchmen living along the line of outcrops. There is scarcely a hill or even an exposure of the sandstone in the Dakota area that does not yield at least fragments of leaves. These fossils are in all states of preservation, from mere traces of nervation to perfect impressions. They vary in size from the tiny *Betulites westii*, scarcely more than a centimeter in diameter, to the magnificent *Sassafras giganteum*, which measures forty centimeters from lobe to lobe.

Of necessity, only impressions of these leaves remain. The vegetable material has long since disappeared, and the most delicate chemical tests, even on those leaves that seem to retain some traces of carbonaceous matter, fail to reveal the presence of either lignin or cellulose. Ordinarily the color of the fossil is the



Liquidambar giganteum Gould, one of the new species of Dakota leaves in the museum of the University of Nebraska.
Photo by Edholm.

same as that of the sandstone in which it is embedded, usually a yellowish brown. Not infrequently, however, especially in the quartz-like rocks, the impressions are almost jet black, and stand out in bold relief to the gray stone. It often happens, especially where the leaves have been enclosed in concretions, that the exposed surface has been polished by the action of the wind and rain until it presents a sleek, glossy appearance. Again, in the softer sandstones the impressions are so fragile that they crumble on exposure, and can be removed, if at all, only with the greatest difficulty.

The history of the subject has been discussed under its proper heading, and only a brief résumé can be given here. The three men who, more than all others, have contributed to our knowledge of the paleobotany of the group are Oswald Heer, J. S. Newberry, and Leo Lesquereux. Professor Heer, of Zurich, Switzerland, was probably the most noted paleobotanist the world has ever known. His knowledge of fossil plants was profound and comprehensive. He described forms from many parts of the world, more especially from Europe and the arctic regions. His connection with the history of the Dakota group is confined to the identification of two collections of plants. The outline drawings of specimens sent him by Meek and Hayden in 1858 were referred by him to the Tertiary, and his position was afterward defended in a series of letters in the Heer-Newberry controversy. Professor Heer also described the collection made by Marcou and Capellini in 1863. The leaves were figured in the paper "Phyllites Crétacées du Nebraska," which is the first printed description, with plates, of Dakota leaves.

Dr. J. S. Newberry, the eminent American geologist, also did much good work in Dakota phytopaleontology. He first identified the leaves of which drawings had been sent to Professor Heer as Cretaceous forms, and enunciated the dictum, which has since been universally accepted, that the essential facies of the Dakota flora did not differ materially from that of the present time. Several papers of importance from the pen of Doctor Newberry were published during the '50s, but owing to a misunderstanding with Doctor Hayden he ceased to interest himself in the subject.

It was Leo Lesquereux, whom Doctor Knowlton justly styles the Nestor of American paleobotanists, who did more than any other man for the cause of the phytopaleontology of the Dakota group. Leo Lesquereux is perhaps the most pathetic figure in American science. Practically exiled with Agassiz and Guyot from his native land at the age of forty years; totally deaf, so that he never heard a word of spoken English; living alone among strangers in a strange land; his whole life filled with hardships and disappointments: nevertheless at his death America lost not only her most distinguished vegetable paleontologist, but also her foremost bryologist. The amount of work he performed was immense; and the record of his achievements will long stand as a monument worthy the emulation of future generations. Doctor Hayden, who made most of the early collections of Dakota leaves, submitted a number of specimens to Doctor Lesquereux for identification; and in 1868 his first publication on the subject appeared. He was at this time sixty years of age. From this date until the time of his death, in 1889, scarcely a year passed that he did not present to the scientific world a contribution to the knowledge of this most interesting subject. The three most important of these publications are: Cretaceous Flora, published in 1874; Cretaceous and Tertiary Floras, in 1883; and The Flora of the Dakota Group, in 1892. This last is Doctor Lesquereux's masterpiece, and was incomplete at the time of his death. The book was edited by Dr. F. H. Knowlton; and the careful manner in which the work was done t[illegible] [illegible] scholarly attainments of the editor.

In regard to the geographical distribution of the flora, it has already been stated that the leaves have been found in every locality that contains Dakota outcrops, and at almost every exposure. They have been collected west of Belvidere, in Clark county; on Bear creek, in the extreme western part of the state; and along the Arkansas river, at Great Bend, Pawnee Rock, and Larned. The region which has yielded not only a greater variety of forms but also a greater number of specimens than any other is also the region in which the Dakota reaches its best development, viz., eastern Ellsworth county, Kansas. This is the famous collecting ground of Mudge, Snow, West, and Sternberg. Leaves are found on Bluff, Thompson, and Oxide creeks, south of the Smoky Hill river; and on the north side, near the towns of Kanopolis, Ellsworth, Carneiro, and Terra Cotta, they may be collected on every hill. Near Brookville and Tescott there are prolific localities, as also in the vicinity of Minneapolis and Glasco. One of the finest collecting grounds known is at Bond's mill, in Washington county, Kansas. From this point leaves are found as far northwest as Fairbury, Neb. Doctor Lesquereux reports leaves from Beatrice. The outcrops of Dakota near Lincoln furnish a few rather poor specimens. Along the Platte river some fairly good leaves have been found. The bluffs of the Missouri from Omaha to Sioux City yield some good leaves, especially points near Tekamah, Golden spring, Decatur, and Blackbird hill, Neb., and Sergeant's bluff, Iowa.

It may not be ill advised to mention in this connection the increase in the number of known species from time to time. Professor Heer, in his "Phyllites Crétacées du Nebraska," discusses seventeen species; in Doctor Lesquereux's first paper, in 1868, fifty-three new forms were mentioned: while in 1874, at the time of the publication of his "Cretaceous Flora," the number had been increased to 130. In his "Cretaceous and Tertiary Flora," in 1883, 190 species are mentioned. The discovery of the magnificent leaf beds in Ellsworth county so increased the number of forms that, when Doctor Lesquereux began his "Flora of the Dakota Group," in 1885, 350 species were known; and the addition of 110 forms from the collections of Sternberg brought the number up to 460. Of these, six are ferns, twelve cycads, fifteen conifers, and 429 dicotyledons. The latter class forms over ninety per cent. of the entire series. Since the appearance of "The Flora of the Dakota Group" comparatively little work has been done on the paleontology of the Dakota. Hollick, Ward, and others have described a few new leaves, probably less than a score of species in all. The collections made in Kansas in 1897 and 1898 by Dr. Lester F. Ward and the writer, and in Nebraska, by the writer, in 1899, have yielded a number of new forms, the greater part of which are now in the museum of the University of Nebraska. (See plate XII.)

In the discussion of the stratigraphy of the group it has been shown that there is no continuity of strata in the Dakota. Sandstones and shales are stratified indiscriminately with clays throughout the formation. This of itself points to changing conditions of sedimentation. It was this marked peculiarity, as well as the manner in which the leaves were deposited, that led Doctor Lesquereux to adopt his views of the manner of deposition of the Dakota, which are now almost universally accepted among students of the group. It is unnecessary to reiterate the statement that, in the main, the opinions of the writer coincide with those of Doctor Lesquereux. For this reason (and even at the risk of being thought to quote too fully), the following paragraphs from this noted author are herewith given. They represent his latest thought, having been written after he had worked over the last collection of Sternberg, shortly before his death:

"In my 'Cretaceous Flora' the question concerning the probable derivation of the numerous vegetable remains found in the shaly sandstone of the Dakota

group, their mode of deposition, etc., have been examined. From the facies and the peculiar distribution of the leaves, it is there admitted that the vegetable remains have been derived from trees or shrubs growing in the vicinity of marshy or muddy bottoms, and that they have been buried or fossilized at or near the place of their growth. This condition is based not only upon the remarkably good state of preservation of the fossil leaves, which are generally found horizontally flattened in the same plane or parallel to that of the deposition of the earthy matter, neither crumpled, rolled, nor lacerated, and with their borders, often even their petioles, attached to them, but also upon the distribution of the leaves, which at different localities generally represent different species, while at a short distance another group of leaves represent other species, genera, or even families.

"These remarks have been lately confirmed by the discovery in Ellsworth county, Kansas, of a very large number of leaves embedded in concretions. These concretionary specimens were found at more than twelve different localities, in groups covering limited areas, the largest tract being about 100 yards, the others not more than seventy yards in width, altogether distributed over a land surface of five to eight square miles. The specimens of each locality were separately collected and were also determined separately, and each lot was found to be composed of from one to three species, and few of them were represented in more than two or three localities. Thus, leaves of *Sterculia* were found in one locality; at another, leaves of *Greviopsis;* in two or three others mostly leaves of *Betulites* were collected; and in others leaves of *Populus kansana*, with *Diospyros rotundifolia*, etc. The leaves forming the nucleus of the pebbles are in a perfect state of preservation, a number of them with their pedicels, or even a small stipule at their base. Of course the fossilization of numerous leaves of the same species in groups, at various more or less distinct localities, gives positive evidence of their growth in that place, or at least quite near, where their remains have been fossilized.

"As yet the relative altitude of the localities where the various groups of specimens have been found has not been fixed, and we do not know whether the diversity of the characters of the plants might not be accounted for by a difference in the horizon of the strata where they have been found, and therefore by a difference of age. Are there peculiar zones in the formation, which might be indicated by marked characters in the vegetation? No answer can as yet be given to the question. The concretionary specimens mentioned above have been found in the so-called highlands of Ellsworth county. But what are those highlands as compared in altitude to the lowlands? Professor Mudge, who has closely searched for the distribution of plants in Kansas, did not find any difference in the character of the plants that seemed to depend on the altitude of the hills. Near Salina I have found the same vegetable species distributed from the base to the top of the hills, the altitude being about seventy-five feet above high-water mark of the river. Hence, it is not possible as yet to consider a difference in the vegetation by peculiar zones like those in the Quadersandstein or Middle Cretaceous of Europe, where zones of the *Liriodendron* or those of the *Crednaria* are mentioned as marking the relative horizons of the strata."[57]

To this it is but necessary to add that later investigations have but corroborated the conjectures of Doctor Lesquereux. Certain genera and species are confined to restricted localities, while others are found in widely separated regions. *Proteoides daphnoganoides*, for example, was one of the species described by Heer in his "Phyllites"; but it has since been found in nearly every locality and horizon throughout the group. *Salix proteæfolia* is another form that is widely distributed. On the other hand, *Betulites*, *Protophyllum*, and many others, although very abundant in certain localities, have never been found elsewhere. *Platanus*, *Sassafras* and *Liquidambar* have been found more abundantly near the base of the group, while *Liriodendron*, *Juglans* and *Aralia* seem to be more common in the upper part. These observations, however, may be simply coincidents; and no particular importance need be attached to them. That a determination of phylogeny of species, if not of genera, in the Dakota group is desirable goes without saying; and the writer confesses to a hope that

[57] Flora of the Dakota Group, U. S. Geol. Surv., Mon. No. XVII, pp. 20-22.

this will eventually be demonstrated. He has constantly kept the matter in mind during the last three field seasons; but at the present time is reluctantly forced to admit that any evidence of plant development from the lower to the higher beds of the Dakota is practically wanting.

That development is shown throughout the various Cretaceous groups, however, may scarcely be doubted. The Cheyenne sandstone, 200 feet below the base of the Dakota, contains a flora which, in general appearance, resembles that of the Amboy clays, or the Tuscaloosa formation, which represent practically the oldest dicotyledonous flora known. The types from these horizons show much less of development than those found in the Dakota. The Laramie flora, which is obtained from beds some 2500 feet above the Dakota, shows considerable advance over the Dakota forms.

The average life of a tree is measured in hundreds of years; that of a marine invertebrate will perhaps not average more than twenty years. As trees are longer lived, so their forms change more slowly in response to environment than animals. The invertebrate fauna of the Cretaceous changes several times from the Cheyenne to the Laramie. A number of forms found in the Champion shell-bed, a narrow horizon at the base of the Kiowa, do not appear higher in the formation. The fauna of the Mentor beds, at the base of the Dakota, is quite different from that of the upper Dakota beds, which resemble the Benton fauna. By the time the upper Cretaceous groups are reached the fauna has again changed. Certain species of plants, however, persist from the Cheyenne to the Dakota, and yet others from the Dakota to the Laramie and even almost to the present time. When the flora of the Cheyenne sandstone shall have been worked up, it should not be thought surprising if it is found that in that formation there are species identical with the Laramie or even later groups. While these statements are true, it by no means argues that the flora as a whole, or even any considerable part of it, is found in different groups. Only a few species, comparatively speaking, persist for any great length of time. Each group is represented in a large degree by forms which are characteristic of it, and are found nowhere else. That plants are more tenacious of life than animals is shown by the fact that there are few genera of fossil plants, even of those as far back as the Dakota, which are not represented in recent floras. A few genera, however, such as *Protophyllum*, *Aspidiophyllum*, and some others, seem to have no affinities among living plants. Either their essential characters have been gradually effaced by rapid modifications, and so intimately mixed with others as to become unrecognizable, or they have been unable to adapt themselves to changed environment and have become extinct.

It is a lamentable fact that plant paleontology has fallen into ill repute both among geologists and botanists. The reasons for this are, perhaps, in many cases legitimate. The botanist, particularly, having before him all parts of living plants—root, stem, leaf, flower, and fruit—is apt to look askance at the work of the paleobotanist, who at best has but one of these organs, and that often in an imperfect state of preservation. He argues, and apparently with reason, that the inferences drawn from such fragmental data are at best imperfect, and consequently misleading; and for this reason is prone to cast aside the work of the paleobotanist as of no permanent value. The botanist is right in considering that a single fragment of a leaf in an indifferent state of preservation is scarcely sufficient data on which to found a new species; nor should he admit that slight variations in the form, margin or nervation of leaves constitute specific differences.

The paleobotanist, on the other hand, insists that while much of his work is of necessity incomplete and must be revised in the light of later discoveri

nevertheless the greater part of it has permanent value. Notwithstanding the fact that the fossils with which he works are extremely unsatisfactory, still there remains a great mass of material which is not only of extreme general interest but also of positive value in determining the age of the rock in which it is found as well as the phylogeny of the plant forms. These statements are ordinarily accepted with more or less of reservation by investigators along other lines.

It is possible that this undesirable condition of affairs has arisen partly from a misunderstanding of terms and partly on account of the methods employed by the paleobotanist. During the early history of this science, as of all others, vegetable paleontologists were too often content with simply multiplying species rather than in working out the phylogenetic problems of plant life. Much of the work will stand; while a great part of it must eventually be revised, as the work of the older botanists has been revised. The work along paleogenetic lines could scarcely have been done earlier because of insufficient data; but the time has arrived when, if paleobotany is to keep pace with other sciences, this vital point may not longer be neglected.

The terms "species," as employed by the botanist and by the paleobotanist are not to be considered synonyms. This fact was tersely stated by Mr. Lesquereux in his first paper, in 1868, as follows: "It is well understood that when the word 'species' is used in an examination of fossil plants it is not taken in its precise sense. For, indeed, no species can be established from leaves or mere fragments of leaves. But as paleontologists have to recognize these forms described and figured, to compare them and use them for reference, it is necessary to affix to them specific names, and therefore to consider them as species."

In other words, the term "species," as it has been employed by paleobotanists, is little more than a convenient handle with which to manipulate certain more or less identical forms. No one who has given the matter any attention can be unaware that the identification of species from leaves alone is in many cases impossible. Leaves of a dozen species of living willows, for example, are so similar in nervation and outline that, if mixed up, they could not afterward be referred to their proper species by any living botanist; while, on the other hand, a dozen leaves taken from the same cottonwood tree might be placed in half that number of different species.

The identification of fossil leaves rests chiefly upon two points: form or outline, and nervation. Of these, nervation is generally considered as determining generic, and outline specific, differences. That these points obtain for some plants appears reasonably demonstrated; but their universal application remains to be proven. The subject of the nervation of dicotyledons has never been worked out, save in a general way, and it is one of vital importance to the science of paleobotany. In view of these facts, then, it would seem that until this question is settled the continued indiscriminate naming of new species on slight and often fancied variations in form or nervation can only add to the apparent confusion into which the science has fallen.

It is not deemed expedient in this connection to enter upon an extended discussion of the genera and species of the group. "The Flora of the Dakota Group" contains practically all the forms so far recorded, and to it the reader is referred for details.

INVERTEBRATES.

The invertebrates found by Professor Mudge in Saline county, Kansas, and considered by Meek and Hayden as representing Dakota forms, are now generally conceded to belong to the Comanche series. The "Mentor beds," as these horizons were termed by Professor Cragin, are now considered as the northern

limits of the Kiowa shale, representing, probably, the extreme limits of the Belviderean sea at the beginning of the Dakota epoch.

The first collection of fossils from this locality contained twelve species. From time to time additions have been made to this number, until probably fifty species have been recognized from these beds. The fossils have all been found in the lower part of the Cretaceous of the region, probably all within 100 feet of the Permian. Above these horizons no more shells are found in the Dakota until the upper layers are reached. Meek and Hayden mention three invertebrates found near the mouth of the Big Sioux river, and a few additional species have since been found in the same locality. Professor Hicks discovered a locality in Jefferson, county Nebraska, from which Doctor White identified seven species. During the summer of 1889 the writer discovered two localities in the upper part of the Dakota from which shells were obtained. One of these is near Glasco, Kan., and the other at Jackson, Neb. The horizon of these widely separated localities is practically the same, being about fifty feet below the base of the Benton. The shells were submitted to Dr. T. W. Stanton, our best authority on Cretaceous invertebrates, and were referred by him to a number of species hitherto found in either the Big Sioux or the Jefferson county localities. Doctor Stanton states that the shells from the Mentor have not been found in the upper layers of the Dakota, and *vice versa*, with the possible exception of some species of *Ostrea* of which the identification is uncertain.

Mr. Logan, however, reports species from the upper beds which are also found in the Mentor. The following quotation is from Mr. Logan's paper: "In the upper Dakota group fossils have been found in three horizons. In the thin sandstone layers of the first shale bed the following fossils were found." [Then follow the names of fourteen shells.] "In the saliferous-shale horizon was found a bed of fossils, of which the following have been determined. . . . Altogether, more than twenty-five species have been found in the Dakota."[58]

Of the shells mentioned by Mr. Logan, at least eight have been recorded as occurring in the Mentor, either in Saline county or near Marquette, while several are among those which have been found only in the upper part of the group. The writer makes no pretensions to a knowledge of invertebrate paleontology, and consequently disclaims the ability to intelligently discuss the question.

VERTEBRATES.

The paucity of vertebrate fossils in the Dakota has long been a matter of note. As late as 1898 Doctor Williston said: "No vertebrate remains of any kind have so far been discovered in Kansas or elsewhere, save some impressions or casts. A record of footprints from this formation was first made by Prof. B. F. Mudge in 1866, and a later one by Prof. F. H. Snow."[59]

The tracks described by Professor Mudge were found by him in the valley of the Republican river, about fifty miles from its mouth. The slab containing the prints was lost at the Kansas agricultural college. It is but just to say that the vertebrate origin of the prints has been questioned, and Professor Mudge himself was led to believe that they were the work of Indians.

The track described by Professor Snow was secured on Thompson creek, Ellsworth county, Kansas, in 1885, by Judge E. P. West.[60] The horizon from which the specimen was taken is about the center of the group. The slab containing the track is now preserved in the museum of the Kansas university. The impression is evidently avian in character, and has been so regarded by vertebrate paleontologists.

58. Univ. Geol. Surv. of Kansas, 2: 212.
59. Loc. cit., 4: 50.
60. Trans. Kans. Acad. Sci., 10: 3.

Since the statement of Doctor Williston, quoted above, two vertebrate fossils have been found in the Dakota. Prof. C. S. Parmenter has recently described a fossil turtle found south of Concordia.[61] The fossil cast is composed of the characteristic red sandstone. It is eleven inches long, nine inches wide, and contains the well-defined impressions of fourteen ribs.

On August 27, 1899, the writer found, at the High banks along the Missouri river, a mile above Decatur, Neb., a reptilian vertebra. The fossil was found embedded in a bank of yellowish clay near the water's edge. The centrum of the vertebra is 70 mm. long, 55 mm. wide, constricted to 35 mm. in the middle, the ends being but slightly concave. Doctor Williston, to whom the fossil was submitted, was unable, on account of its imperfect state of preservation, to identify it with certainty, but considered it the vertebra of either a crocodile or a dinosaur.

CONCLUSION.

The Dakota Cretaceous as a group is widely but not thoroughly known. Its history dates from 1804, when Lewis and Clarke first described the hills of soft, yellow sandstone near Sioux City. The controversy concerning the age of the group, waged by Meek, Hayden, and Newberry, against Swallow, Hawn, Marcou, and Heer, occurred from 1855 to 1864. The men who have written most extensively concerning the group, besides those just mentioned, are White, Ward, Hay, Mudge, and especially Leo Lesquereux.

The Dakota extends from southwest Kansas to northeast Nebraska, along a line over 500 miles long. The region of outcrops along this line approximates thirty miles in width. It reaches its greatest development in central and northern Kansas. To the northeast and southwest of this region post-Cretaceous erosion and deposits have so modified the Dakota that the outcrops are usually restricted to lines of bluffs or isolated exposures.

The rocks of this group rest either conformably on the Comanche Cretaceous, or unconformably on the Permian or Carboniferous. The line of demarkation between the Comanche and the Dakota has not been sharply drawn; and, in the light of our present knowledge, such a line is impracticable. The Dakota grades upward into the Benton wherever the latter is present; otherwise the upper limit is marked by a line of unconformity below Cenozoic rocks. The stratigraphy of the group has not been well understood. Instead of consisting almost exclusively of sandstone, it is found that the greater part of the entire thickness is composed of clays and shales. There is no general continuity of strata, the various members appearing and disappearing without seeming regularity. The origin of the rock is probably estuarine or beach deposits under changing conditions of elevation. Besides the ordinary forms of stratigraphy, many peculiar phases may be observed, such as concretions, gravel-beds, quartz-like ledges and the like.

The stone of the Dakota is used for building purposes to only a limited extent. The clays, however, are destined to become an important economic factor. An excellent quality of brick and tile has been manufactured from this clay in several localities. Coal is mined in limited areas in northern Kansas, but is inferior both in quality and quantity. Sand is plentiful but is not in great demand. The few deposits of gravel in the formation are being utilized by railroad companies.

The water-supply is inexhaustible. The Dakota sandstone is the great water holder of the plains. The origin of the water has been assigned to three sources, viz.: Artesian flow from the mountains, sheet water, and local rainfall. Springs everywhere present and constitute an important economic phase of the group.

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[61] Loc. cit., 16: 17.

The salt-springs and marshes, which are found in northern Kansas and at Lincoln, Neb., obtain their flow from a bed of saliferous shales near the upper part of the formation.

The fossils consist of plants, invertebrates, and vertebrates. Of these, plants greatly predominate. Over 500 species are found in the group, of which more than ninety per cent. are dicotyledonous leaves. Shells are found in the lower parts of the group, while vertebrates are represented by impressions of bird tracks, a fossil turtle, and a reptilian vertebra.

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The chronological order has been observed, in order to show more clearly the development of the subject; but an alphabetical index at the close will aid in locating any particular paper. Complete titles are given unless they are so long as to be unwieldy. In references to periodicals, abbreviations are used as much as possible. The abbreviations vol. and pp., however, are usually omitted, and a colon is used to separate volume and page; thus: Proceedings of the Philadelphia Academy of Science, volume VIII, pages 26 to 38, is written: Proc. Phila. Acad. Sci., 8: 26-38. The dates under which the articles are arranged are those of the year of publication as indicated by the title-page.

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ON THE SOUTHERN EXTENSION OF THE MARION AND WELLINGTON FORMATIONS.

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Read before the Academy, at Topeka, December 28, 1900.

In southern Kansas the Marion and Wellington formations include all the upper Paleozoic rocks between the top of the Flint hills and the base of the Red Beds; or, in other words, between the Chase of Prosser[1] and the Harper of Cragin.[2] According to Cragin's classification, these two formations are included in the upper or Sumner division of the Big Blue series, immediately subjacent to the Cimarron series.

The lower or Marion formation, as first described by Prosser,[3] consists of some 400 feet of rather soft gray or buff, fossiliferous limestone, alternating with variously colored shales and marls. The name is from Marion county, where the formation is well exposed. To the rocks comprising approximately the same formation Cragin afterward applied the term "Geuda salt measures."[4] By the law of priority, however, the first name has continued to be used, and the latter has been dropped from the nomenclature of the region. It is in the Marion that the magnificent salt beds of central Kansas occur, and it is the leaching out of the brine from these beds as they approach the surface to the east that produces the salt-springs and wells along the line of outcrops. Of these, the Geuda springs are perhaps the most noted. The limestones of the lower part of the Marion contain the most typical Permian fauna to be found in the West.

The term "Wellington" was first applied by Cragin[5] to the shales formerly described under the term "gray shales" by Robert Hay. Professor Hay used the term in contradistinction to the "red shales" of the Red Beds further west.[6] The Wellington, as described by Cragin, consists of several hundred feet of gray, red, green and blue shales and clays, containing occasional impregnations of salt, gypsum, and dolomite. The line of separation between the Marion and Wellington has never been sharply demarked. The same difficulties are encountered here as in the classification of the various formations of the Red Beds, viz.: absence of fossils, and such gradual change in the lithological character of the rock that hard-and-fast lines may rarely be drawn.

The line of separation between the Wellington and Harper, in other words, between the Big Blue and the Cimarron, is perhaps more easily located. The change from the gray and blue shales of the former to the prevailingly red sandstone of the latter is comparatively rapid, and in not a few localities the line of division may be definitely located. In a paper describing the stratigraphy of the region of McCann's quarry, near Nardin, Okla.,[7] in which fossils were first found in the Kansas-Oklahoma Red Beds, this fact was emphasized. In this region the green, gray and blue shales of the Wellington are succeeded by a fossiliferous ledge of sandstone three to six feet thick. This ledge, known as the McCann sandstone, is considered the basal member of the Harper, or Cimarron, series. The ledge contains vertebrates, invertebrates, and leaves. The McCann sandstone may be traced for a number of miles throughout Kay and Noble counties, Oklahoma, and serves as a guide for the stratigraphical work of the region.

1. Journal of Geology, vol. III, No. 7, pp. 771-786. 1895.
2. Colorado College Studies, vol. VI, pp. 18-20. 1896.
3. Loc. cit., pp. 786-789.
4. p. 9.
5. Loc cit., p. 16.
6. Seventh Biennial Report
7. Kans. Univ. Quart., [illegible]

The base of the Marion is fixed by both Prosser and Cragin at the Winfield concretionary limestone.[5] This is a prominent ledge that extends from Marion county southward, forming the escarpment west of the Walnut river almost from its source to its mouth, as well as numerous mounds and bluffs to the east of this stream. It is well exposed near Winfield and Arkansas City, and extends into Oklahoma as far as the vicinity of Ponca City and White Eagle. The top of the Wellington being at the line of contact of that formation with the overlying Red Beds, it follows that the line of the eastern outcrops of the Red Beds will also be the western limit of the Wellington. The northern exposure of the Red Beds seen by the writer is near Arlington, western Reno county. From this point the eastern limit of these beds may be traced southeast along a line passing near Castleton, New Murdock, Norwich, and Argonia, to the vicinity of Caldwell. In southern Kansas, then, the Marion and Wellington formations occur in the following counties: Western Marion, Butler, and Cowley; practically all of Harvey, Sumner, Sedgwick, and McPherson, and eastern Reno and Kingman. Throughout a great part of this area the Paleozoic is covered with post-Mesozoic formations; notably the Equus beds of McPherson, Harvey, and Reno counties. These formations, however, will not be discussed in this connection.

A glance at the map will show that, along the parallel of the north line of Sedgwick county, the two formations under discussion occupy an area sixty miles wide from east to west. On the state line, sixty-three miles south, the distance across the area is not to exceed thirty miles. It will also be seen that this contraction of area southward is caused by the southeast trend of the line of eastern outcrops of the Red Beds. The Winfield concretionary limestone at the base of the Marion trends approximately north and south.

Bearing in mind the conditions in southern Kansas, we will next turn our attention to the rocks of northern Oklahoma, in order to ascertain whether or not like conditions obtain in this region. As stated above, the Winfield concretionary limestone continues uninterruptedly southward beyond Ponca City. In eastern Kay county it forms the uppermost of a number of heavy flint-bearing limestones, the western extension of the Flint hills, that outcrop along the bluff west of the Arkansas river. To the south the ledge appears to thin out, as do all the limestones of the region, and has not been recognized as far south as the Otoe reservation, although a thin stratum of limestone north of the Otoe agency may be referred to the same ledge. As stated above, the western limit of the Wellington in northern Oklahoma is the line of the outcrop of the McCann sandstone. The most northern outcrop of this rock, so far as known, is on Deer creek, five miles southeast of Nardin, Kay county, and thirty miles southeast of Caldwell, Kan. From this point this ledge has been traced southeast, past the Eagle's Nest quarries, south of Tonkawa, to the vicinity of Redrock, a station on the Santa Fe in the Otoe reservation. The blue and green shales of the Wellington are found, however, as far as Perry and the southern part of Noble county. In the vicinity of Ingalls, in eastern Payne county, thirty miles southeast of Perry, the typical Red Beds shales and sandstones are found in connection with the fossiliferous, flinty limestone, which here represent the southern extension of the Flint hills.

The area of outcrops of the Marion and Wellington formations in Oklahoma, then, may be compared to a right-angled triangle, with the right angle located near Arkansas City, Kan. The state line from Arkansas City to Caldwell is one leg of this triangle, and the line of outcrop of the Winfield concretionary limestone from Arkansas City to Redrock is the other leg. The hypothenuse is along

5. Univ. Geol. Surv. of Kansas, vol. II, 186, p. 84.

the line of outcrop of the McCann sandstone, from Caldwell to Redrock, a distance of fifty miles. The area occupies the greater part of Kay and a small part of Noble and Grant counties.

The work already done on the geology of the region is but fragmentary. The data collected on one or two reconnaissance trips, made at various times, constitute almost all of the available information at present. Although no fossils have been found in these formations in Oklahoma, it is now known that the horizons immediately sub- and superjacent contain organic remains; and it is by no means improbable that research will reveal fossils in these beds. The lithological character of the rock is, in some cases, of especial significance. It may often be observed that a shale bed becomes distinctly arenaceous to the south, so much so that in many instances the lithology changes entirely, and the rock will become a true sandstone. Further south in the territory there are several hundred feet of gray and brown sandstones and shales below the Harper, for which the name Stillwater sandstone has been proposed. It may eventually be proven that the Stillwater is but a southern continuation of the Sumner. While no attempt has been made to correlate these rocks with the Texas beds, it may not be considered improbable that future investigation will demonstrate that the Wichita beds south of the Arbuckle mountains are contemporaneous in time with the Salt Fork or lower division of the Red Beds in Kansas and Oklahoma.

The investigations of the Oklahoma Geological Survey during the past summer revealed the fact that the ledges of limestone and shale that form the Flint hills thin out to the south and disappear before reaching the middle of the territory. The culmination of these hills is evidently in eastern Cowley county. Even within Kansas, however, ledges of sandstone appear near the top of the Flint hills. These sandstones become more pronounced to the south, and in the southern part of the Osage nation occupy perhaps half of the thickness of the formations. In eastern Payne county, Oklahoma, and the northwestern part of the Creek country only a few comparatively thin ledges of limestone remain, and in Lincoln county the last of these disappears. Along the line of the North Canadian, from Oklahoma City to Okmulgee, no limestone appears. In this region only sandstones and shales occur.

From what has preceded, it will appear that south of the Kansas line the Carboniferous sandstones from the east and the Red Beds from the west gradually approach each other. At the same time, the Flint hills and the Sumner division become less and less pronounced, until, in central Oklahoma, both of these divisions have disappeared and sandstones and shales occupy the entire area.

THE OKLAHOMA SALT PLAINS.

BY C. N. GOULD, NORMAN, OKLA.

Read before the Academy December 28, 1900.

There are in the Permian rocks of Kansas and Oklahoma two distinctively saliferous horizons. To these Cragin, in his article, "The Permian System in Kansas,"[1] gave the name Geuda salt measures and Salt Plain measures. Prosser's name, Marion,[2] however, had priority over the term Geuda salt measures, and is now in general use.

The Marion formation lies immediately above the Flint hills. It consists of from 400 to 500 feet of saliferous and gypsiferous shales and clays, with a considerable amount of fossiliferous limestone in the lower part. The salt obtained

1. Colorado College Studies, vol. VI, p. 9. 2. Journal of Geology, vol. III, No. 7, p. 786.

at Hutchinson, Lyons, Kanopolis, and other Kansas points is from this formation. Along the eastern outcrop of this saliferous horizon, in Cowley, Sumner, Sedgwick, Butler, and Harvey counties, Kansas, the water is often distinctly salty. In the vicinity of Geuda Springs there some small salt plains, but in comparison with those referred to later in this article they are scarcely worthy the name.

The Marion is succeeded above by the Wellington, and this in turn by the Harper.[3] These two formations, which approximate 1100 feet in thickness, are composed throughout of variously colored clays, shales, and sandstones. In the Wellington the clays and shales are prevailingly blue, green, or gray. In the Harper the color is normally a brick red. Throughout both formations there is a great quantity of mineral salts. Of these, gypsum and common salt predominate, although magnesia, borax, dolomite, and others are not infrequent. These minerals seem to increase in amount toward the upper part of the formations. The salt particularly appears to reach its culmination in the Salt Plain measures which lie upon the Harper.

Stratigraphically, the Salt Plain is the most unsatisfactory formation in the Kansas-Oklahoma Red Beds. Indeed, it is still an open question whether it would not be wise to either assign it to subformation rank under the Harper or drop it altogether from the nomenclature of the series. In discussing the formation, Professor Cragin himself says: "The Salt Plain measures force themselves upon us as a very pronounced and, if interrupted, persistently recurring saline horizon."[4] It is not doubted that the saliferous sandstones and shales are of frequent occurrence in the middle Kansas-Oklahoma Red Beds. Nor is it questioned that the culmination of these measures is below the Gypsum hills. But that all or even a greater part of these measures are confined to a definite horizon remains to be proven. In fact, it has been demonstrated that the largest salt plain in Oklahoma—the Salt Fork plain—is located near the middle of the Harper.

The Salt Plain formation, as described by Cragin, outcrops along a line skirting the east flank of the Gypsum hills, from Barber county, Kansas, as far south as the Canadian river. According to his last classification, it lies between the Harper and the Glass Mountain formations;[5] the Harper comprising the large level area in southern Kansas and central Oklahoma, and the Glass Mountain including the eastern slope of the Gypsum hills. Of the four large salt plains in Oklahoma, at least three may be definitely assigned to this horizon. These are the Big Salt plain, and Little Salt plain of the Cimarron, situated in the northern part of Woodward county, and the Salt Creek plain, in northern Blaine county. The latter is located near the head of Salt creek, a tributary of the Cimarron. In every case these plains are situated in cañons at the base of the Gypsum hills, and from 150 to 200 feet below the heavy ledges of gypsum which cap these hills.

Perhaps the most noted of the salt plains, from the standpoint of a historian, is the Big Salt plain of the Cimarron. The first white man to visit this place was probably Coronado, in his journey across the plains in search of the seven cities of Cibola. In regard to this event, Mr. J. R. Mead says: "The route or trail of Coronado, in his famous expedition from the Pueblos of New Mexico across the prairies of Kansas to the populous tribes of the Missouri, will ever remain an open question. The only point that we can locate with reasonable certainty is the salt plain of the Cimarron, just within the Kansas line—the only

3. Colorado College Studies, vol. VI, pp. 16, 18.
4. American Geologist, vol. XIX, No. 5, May, 1897, p. 352.
5. *Ibid.*, p. 363.

place where rock salt can be obtained on the surface in all the plains country. This salt was known and used by the Indians, and was an article of trade from the Gulf to the British line, and this locality was a well-known geographical point, from which distances were reckoned."[6] The presence of a dozen or more trails, now nearly obsolete, radiating from the plain like spokes of a wheel, bears testimony to the fact that this place was long used as a source of supply of salt to the various forts and settlements of the surrounding regions. Indeed, it is but a few years since salt from this plain was hauled for hundreds of miles in all directions, and not until the time of the discovery of extensive beds in central Kansas did this industry wane.

The Big Salt plain proper extends for eight miles or more along the Cimarron river. In width it varies from half a mile to two miles. On the south bank the bluffs of red shale and sandstone capped with gypsum rise directly from the edge of the plain to the height of 100 feet or more. North of the plain these bluffs are not so steep, and are at a distance of a half mile or more from the plain. Even here, however, the sinuous white line of gypsum may be traced along the tops of the bluffs as far as the eye can reach. In other words, the plain lies in the broad cañon of the Cimarron, enclosed on both sides by gypsum-capped bluffs of red shale.

The plain is flat and as level as a floor, except for a few meandering channels which, in wet weather, contain a small stream, but are ordinarily dry. After a rain it will sometimes happen that a stream of considerable volume flows over the plain, but during the summer months nearly all the water either evaporates or sinks into the sand. In places where a small stream still runs down the channel, the water is often so salty that a thin crust of crystal white salt forms on the surface, resembling nothing so much as a sheet of ice across a small stream in winter. The entire plain is covered with a thin incrustation of snow-white salt crystals. In most places this incrustation is not to exceed an eighth of an inch thick, but it reflects the sunlight and blinds the eye like a snow field. Especially if the wind be blowing the small particles of salt, a walk across the plain makes the eyes smart and burn in a manner not easily forgotten.

In a large cove on the south side of the plains proper, there are a number of salt springs which boil up out of the flat surface of the plain. The water is crystal clear, and it sometimes requires more than ocular proof to convince one that it contains nearly fifty per cent. of salt. There are scores, perhaps hundreds, of these springs on an area a few acres in extent. Some of them flow streams as large as a man's arm; others are much weaker. In all cases their presence is marked by a conspicuous white incrustation of salt, which forms around the spring and along the sides of the little stream that flows from it. Particles of grass or weeds blown into these springs or streams soon become covered with white salt crystals. These strings of crystals are often an inch or more in diameter and look like rock candy. In places the incrustations around the springs are so thick that the salt may be scraped up and hauled away. This is the source of the so-called rock salt of the plain.

The Little Salt plain is located a few miles further up the Cimarron, just on the border of Kansas. It does not differ materially from the plain just described, except that it is much smaller and the bluffs on either side of the river are neither so high nor precipitous.

Besides the two plains of the Cimarron, the Salt Creek plain, in northern Blaine county, also belongs to the Salt Plain formation. Like the others, it is located in a cañon at the foot of the Gypsum hills. This plain is much smaller

6. Kans. Hist. Coll., vol. V.

than the Big Salt plain just described. It is not to exceed a quarter of a mile wide in the widest place, and for the greater part of its course is not more than 100 yards in width. It is perhaps three miles long.

The region of Salt creek is one of the most picturesque spots in Oklahoma. The upland covered with jack-oak-bearing Tertiary sands breaks off into precipitous cliffs and cañons 200 or more feet deep. The slopes of these cañons are composed of the brick-red shales of the Glass Mountain formation, and are capped by the massive white ledges of gypsum and dolomite of the Cave Creek formation. Dozens of narrow cañons with cedar-covered slopes radiate outward from Salt creek and its tributary, Bitter creek. It is in the head of the main Salt Creek cañon that the springs which supply the plain are found. A fifteen-foot ledge of red-and-blue-mottled, cross-bedded sandstone outcrops in the heads of several branches of the main cañon. It is from this saliferous sandstone that the springs issue. Along the bottom of the cañon salt incrustations cover a narrow strip 100 yards or more in width. A mile below the springs the cañon widens out and the creek leaves the wall of hills and enters the flat country. The salt plain spreads out, and in one place becomes perhaps a quarter of a mile wide. A mile or so down the creek it is joined by other streams and soon loses its individuality.

From the standpoint of economic importance the Salt Creek plain exceeds all others in the territory at the present time. A number of primitive salt plants are located along the edge of the plain. The methods employed in the evaporation of salt are extremely simple. A well is dug in the soft sand of the plain, and the water pumped by hand into vats and evaporated by boiling. It is stated that three buckets of brine make one of salt. The capacity of the best plant running at the present time is approximately 2000 pounds per day. The salt is hauled in wagons to supply local trade. The demand is said to exceed the supply for a part of the year. There is enough brine in this locality alone to make a number of car-loads of salt a day.

The largest salt plain in Oklahoma, however, is not near the Gypsum hills, nor even in the region of outcrops of the Salt Plain formation. It is in the northeastern part of Woods county. The nearest point of the Gypsum hills is at least thirty miles from this plain. As stated above, the geological horizon is well down in the Harper, perhaps 200 feet below the top of this formation. This plain is the only one in the territory that is not located on the waters of the Cimarron. It is usually known as the Salt Fork plain, from its position on the Salt Fork of the Arkansas. The plain occupies an area approximately eight miles north and south and six miles east and west. The greater part of the plain lies south of the river. It is as level as a floor and absolutely bare of vegetation. Only here and there does an occasional bit of driftwood break the dreary monotony. On a warm day a view across the snow-white plain stretching away into the seemingly infinite distance will often reveal a mirage shimmering along the horizon. Trees, watercourses and cultivated fields stand out in bold relief, and so natural do they appear that one may sometimes be tempted to believe that they are more than mere optical illusions.

FAUNA OF THE PERMIAN OF THE CENTRAL UNITED STATES. PART I.

BY J. W. BEEDE.

Read before the Academy December 29, 1901.

It is proposed to give under the above title a discussion of the stratigraphy, fauna and faunal relationships of the Permian of the Mississippi valley. An article is now in preparation on the fauna and stratigraphy of a portion of the Lower Permian (below the Red Beds). A preliminary note on the fauna of the Upper Permian (Red Beds) may be found in the forthcoming report of the Oklahoma Geological Survey.

The object of this paper is merely to bring to notice a few very interesting species not heretofore known, leaving most of the discussion of them to the later paper, where the fauna will be discussed more fully and the descriptions and figures of the fauna as a whole given.

NEW SPECIES FROM NEBRASKA.

The fossils herein described are from a valuable collection made in Gage county, Nebraska, by Prof. W. C. Knight. The discussion of the geology of this region will be found on page 357 of the eighth volume of the Journal of Geology.* The specimens herein described are now in the museum of the University of Nebraska.

Aviculopecten nebrascensis, n. sp. Plate XIII, figs. 3–3d.

Shell moderately large, quite convex, somewhat resembling *A. occidentalis* Shum. in general appearance. The posterior ear of the left valve is moderately small, the posterior margin being only slightly sinuated below it. The anterior ear is moderately well rounded in front, with deep sinus below; sulcus between the ear and body of the shell not very well defined. Hinge line about two-thirds the length of the shell; beak widens rapidly, slightly protruding. Except near the ears, the shell is moderately regularly rounded. The surface is marked by radiating striæ or costæ, sometimes wavy, and occasionally one is larger than the majority, increasing by implantation. The right valve is flat, with the byssal notch extending to the body of the valve; the markings of the body of the valve similar to those of the other half of the shell. Length, 33 mm.; height, 31 mm.; convexity, 10 mm.; length of hinge, 21 mm.

Permian, Gage county, Nebraska.

This species seems to be derived from *A. occidentalis*, and differs from it in the small posterior ear, great convexity, and the wide-angled beak.

Pinna? coprolitiformis, n. sp. Plate XIII, figs. 1, 1*b*.

Shell moderately small for the genus; angle of divergence large; hinge nearly straight; ventral margin apparently irregular; anterior end blunt. The entire shell is wrinkled vertically and has little the appearance of the usually graceful species of the genus. The markings and lines of growth are very indistinct in our specimens. These markings are very much like those of *Aviculopinna*, but are very faint and very fine. Length, 50 mm.; height in widest portion, 30 mm.; convexity, about 22 mm.

Permian, Gage county, Nebraska.

The generic position of this fossil is uncertain, as the beak is not well preserved. It seems to have more nearly the general form of a *Pinna* than of an

*See, also, an article on the Blue Valley Permian, by the writer, in the Kansas University Quarterly for July, 1900, vol

Aviculopinna, and it is provisionally referred to that genus. It is liable to be confounded with no other species of either genus. It is much more liable to be mistaken for a coprolite.

Aviculopinna knighti, n. sp. Plate XIV, fig. 2; plate XIII, fig. 6.

Shell extremely large, slightly arcuate, compressed laterally, and having a very small angle of divergence at the end. Cardinal ridge small compared with the size of the shell. The striæ meet the hinge at about a right or slightly oblique angle. They pass downward to about the middle of the shell, where they turn forward, as common among species of the genus. Both ventral and dorsal margins are similarly, though slightly arcuate. Length, 22 inches, with about a foot missing; height at widest place, 83 mm.

Permian, Gage county, Nebraska.

The beak of this fossil is missing, but the form and markings are such as to place it with all probability among the species of this genus. The young specimens of this species are remarkably long and narrow, presenting a peculiar appearance. It is named in honor of Professor Knight, who collected the type.

Aviculopinna nebrascensis, n. sp. Plate XIV, figs. 1–1d.

Shell moderately large, roughly triangular, compressed laterally, widening rapidly toward the posterior. Hinge line straight; marginal ridge moderately prominent; ventral margin slightly arcuate; posterior extremity meeting the hinge at an obtuse angle, the lower third rounding forward to meet the ventral margin. Beak very indistinct and very near the anterior end of the shell. The surface is marked by striæ passing slightly backward and downward two-thirds or three-fourths the distance across the shell, where they curve rather abruptly forward and downward, finally reaching the ventral margin as they fade out. The lines, as shown in the cast, are fairly approximate and not very prominent. They appear to be nearly parallel to the ventral margin on the lower quarter of the shell. Length, 107 mm.; height a little in front of the posterior end, 41 mm.

Permian, Gage county, Nebraska.

This species differs from *A. illinoiensis*, which it most resembles, in being higher, in having a straight hinge, less distinct markings, and larger. It differs from *A. pinnæformis* Geinitz, from the Permian of Europe, in not having any radiating striæ.

EXPLANATION OF PLATE XIII.

Pinna? coprolitiformis.

1. View of left side of specimen.

1*b*. Diagrammatic reproduction of the striæ from the middle to ventral margin of the opposite valve of another specimen.

Allorisma sp.

2 and 2*b*. The two valves of an *Edmondia*-shaped *Allorisma*.

Aviculopecten nebrascensis.

3. Flat valve, showing byssal notch.

3*b*. Convex valve, cast, showing form and markings.

3*c*. Outline of the same, showing convexity.

3*d*. Larger specimen, with wavy striæ and straight posterior side of shell.

5 and 5*b*. Pedicle and posterior view of an undetermined brachiopod.

Aviculopinna knighti.

6. Left valve of specimen as it appears, one-fourth natural size. All other specimens natural size.

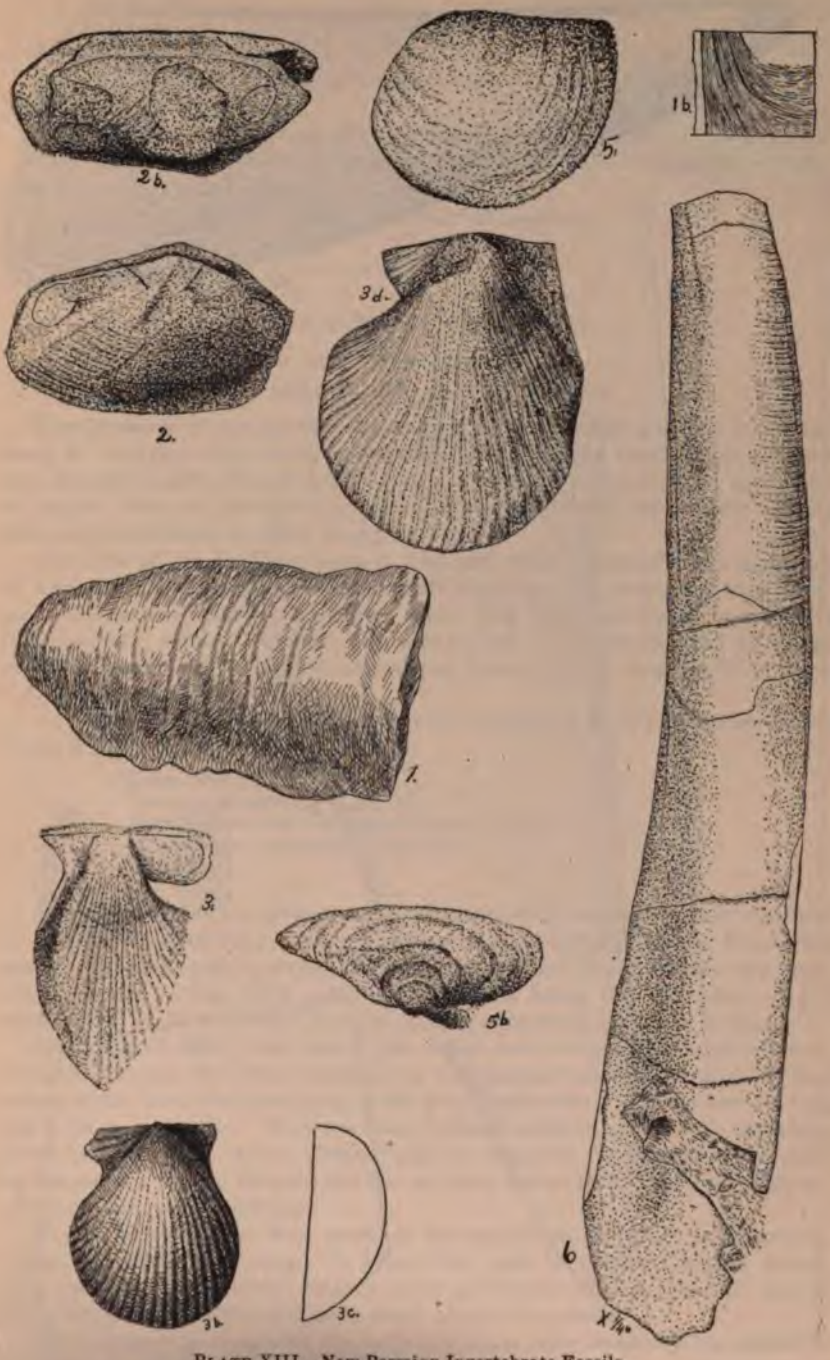


PLATE XIII. New Permian Invertebrate Fossils.
Drawn by J. W. Beede.

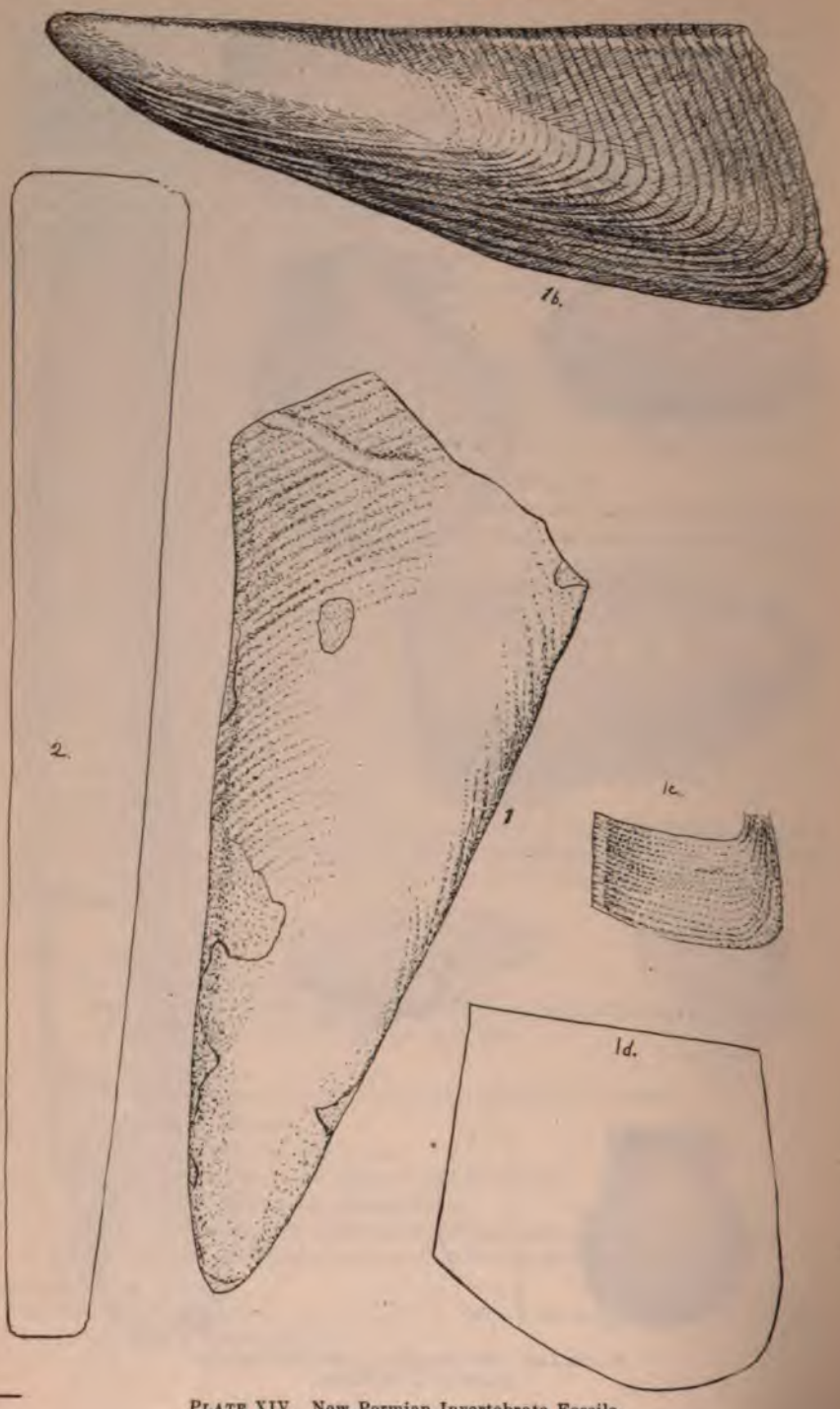


PLATE XIV. New Permian Invertebrate Fossils.
Drawn by J. W. Beede.

EXPLANATION OF PLATE XIV.

Aviculopinna nebrascensis.

1. Concave cast of valve, showing markings.

1*b*. Cast of type.

1*c*. Portion of another cast, showing direction of markings.

1*d*. Figure showing outline of posterior of shell. All natural size.

Aviculopinna knighti.

2. Outline of young specimen. One-half natural size.

THE AMERICUS LIMESTONE.

BY ALVA J. SMITH, EMPORIA.

Read before the Academy December 28, 1900.

The limestone under consideration in this paper is called the Americus limestone on account of its being extensively quarried near that village. It was thus denominated by Kirk in his Neosho river section, and is referred to by him on page 80, volume I, of the University Geological Survey, but it seems to have escaped identification in other localities.

The color of the Americus stone is a neutral drab, weathering to a light buff on account of the oxidation of the iron it contains. Its texture is even, compact, and semicrystalline; hardness, three. Its thickness varies in different localities, from sixteen to twenty-two inches, and it may be obtained in blocks of any required size. All points considered, it is by far the best building stone in Lyon county.

An analysis of the stone yields the following elements, approximately in the proportions given, viz.:

Silica (SiO_2)	6
Calcium carbonate ($CaCO_3$)	75
Aluminates and ferrous carbonate ($FeCO_3$)	12
Magnesium carbonate ($MgCO_3$)	6
	101

Fossil fauna are quite abundant, the upper portion containing great numbers of *Fusulina cylindrica;* while crinoid stems, *Productus costatus*, *Productus semireticulatus*, and *Spirifer camerata* and a species of *Retzia* are occasionally found in the lower portion, the *Retzia* being very abundant in the shale above, while the yellow shale beneath is apparently barren of fossils.

The adjacent strata, both above and below, are a series of thin-bedded limestones and shales, the shale assuming an arenaceous character about thirty feet below, while thirty-five feet above is the most productive *Fusulina* horizon that has come to my notice. They are there bedded together in a friable limestone about four feet thick, which disintegrates on exposure, freeing the little fossils by the million, so that they fill the soil in many places for hundred of yards below the outcropping formation.

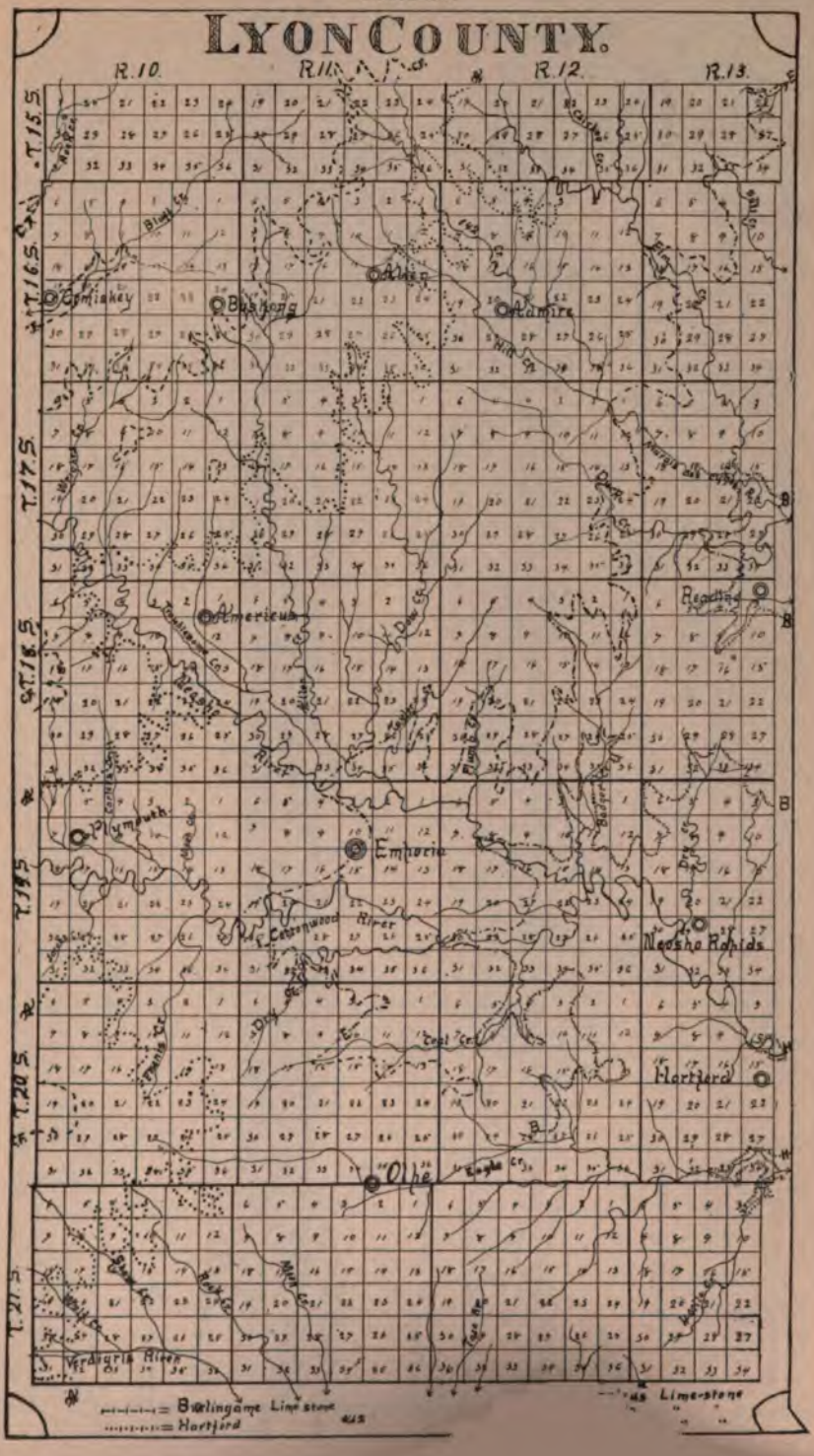
There is a locality on Wolf creek, in the southwest corner of Lyon county, section 19, township 21, range 10, where they may be gathered with a shovel. This horizon is a prominent feature in the series and may frequently be used to locate the position of the Americus stone when it is covered.

The outcropping margin of [illegible]v usually be recognized at a distance by the large, re[illegible]vs in evidence where the ground surface is at [illegible]n to twenty feet are

of frequent occurrence in the southwest part of the county. The outcrop enters the county near the southwest corner and is found along the bluffs on the south side of the Verdigris river, elevation, 1225 feet above sea-level; trending up the river into Chase county, it crosses, and reappears in Lyon county, in the hills immediately north of the river. Thence it follows generally a northeasterly direction, for eight miles, to a point in section 1, township 21, range 10, where it attains an altitude of 1325 feet. Thence it trends northward to the hills one mile south of Phenis mound. Thence northwesterly, skirting the hills along the head waters of Phenis and Jacobs creeks, it leaves the county, passing under the Cottonwood river one mile southwest of Saffordville, in Chase county; elevation, 1110 feet. Thence it reenters the county in section 6, and extends in a sinuous line to the corner common to sections 23, 24, 25, and 26, township 18, range 10, where it is extensively quarried on the old Ruggles farm, at an altitude of 1222 feet. For the next eight miles the general trend of the outcrop is northwest; returning to within one and a half miles of the west county line, it passes under the Neosho river; altitude, 1130 feet; thence its course is nearly east six miles. Thence it bears east of north in a zigzag line, passing between Allen and Admire, at an elevation of 1300 feet, where it is quarried for shipment on the Missouri Pacific road. It leaves the county near the center of the north line.

The dip of the stone throughout the county is about twenty-five feet to the mile, fifteen degrees north of east.

Quarries and typical exposures are indicated on the map.


LYON COUNTY.
R.10.
R.11.
R.12.
R.13.
T.15.S.
T.16.S.
T.17.S.
T.18.S.
T.19.S.
T.20.S.
T.21.S.
Emporia
Americus
Admire
Olpe
Hartford
Neosho Rapids
Reading
Bushong
Allen
Miller Creek
Cottonwood River
Verdigris River
Burlingame Limestone
Hartford
Limestone

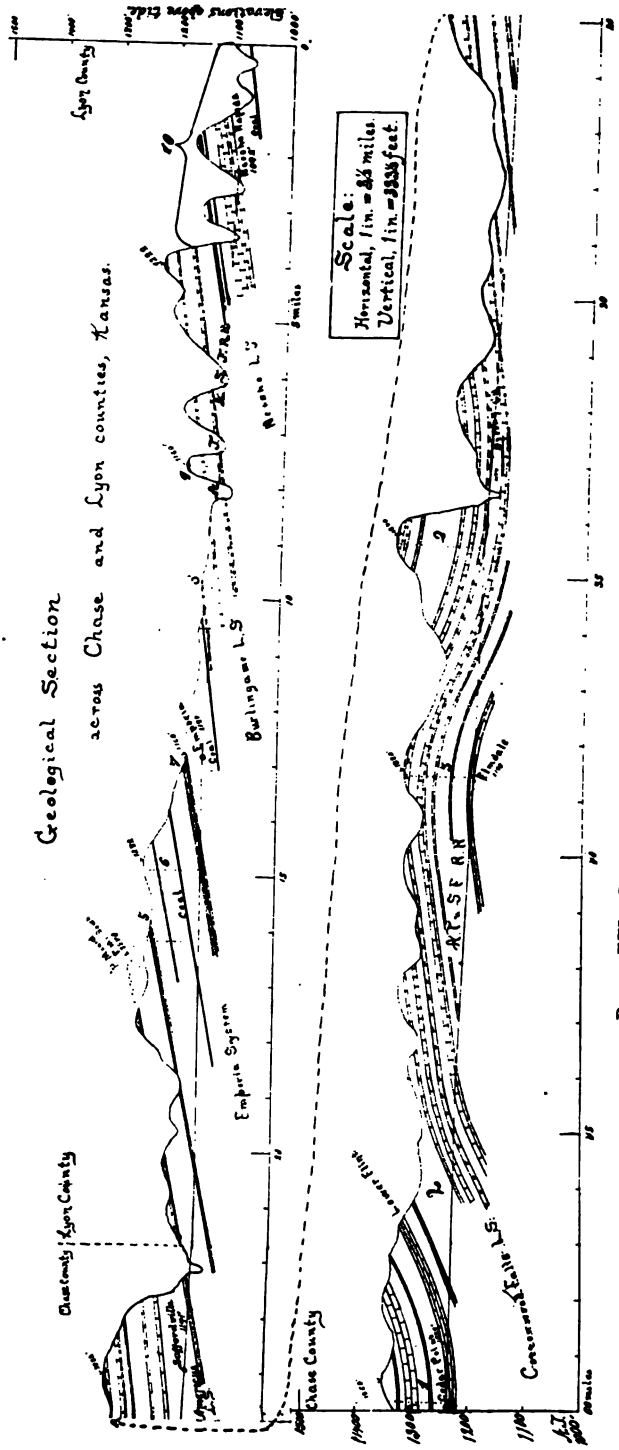


PLATE XVI. Geological section across Lyon and Chase counties.
Drawn by A. J. Smith.

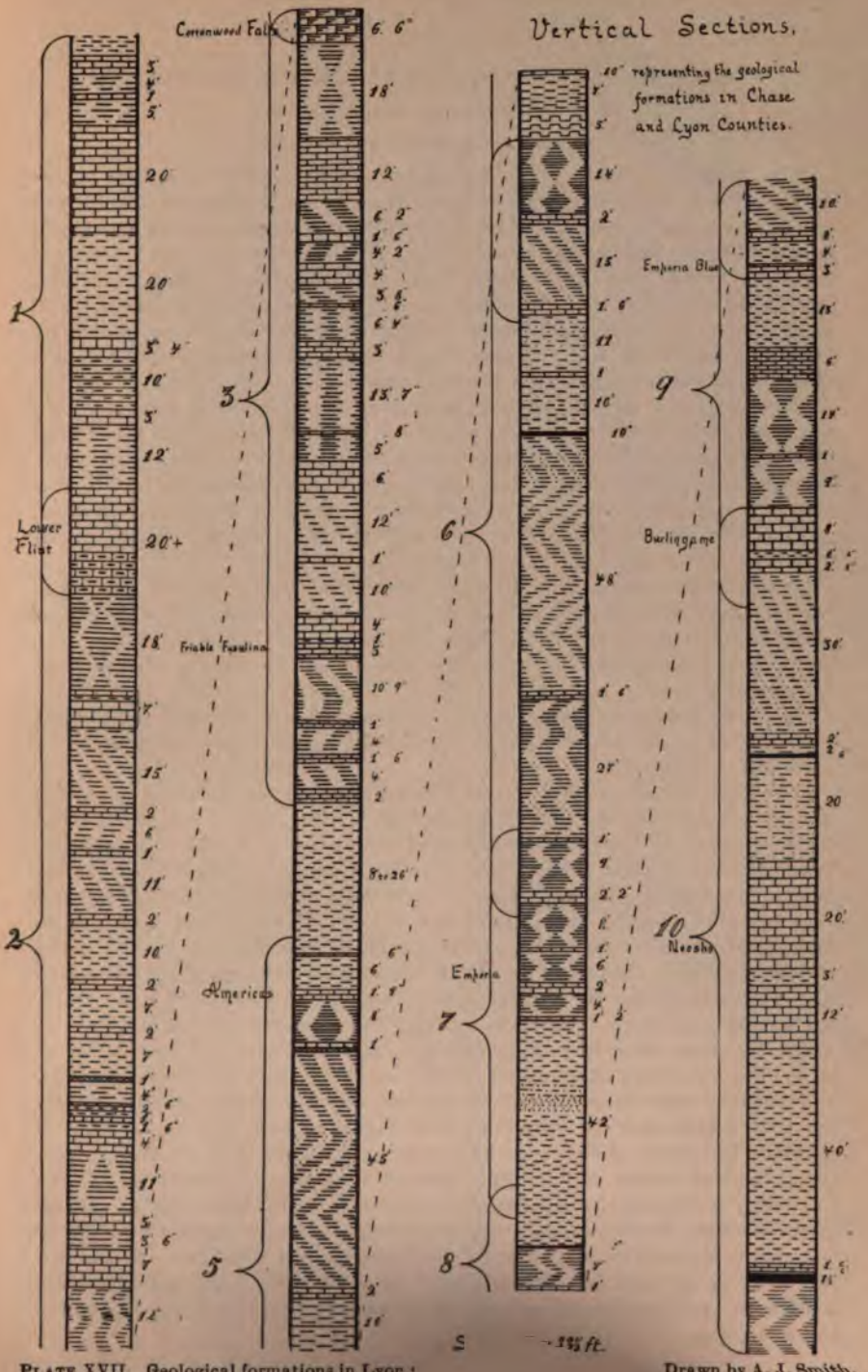


PLATE XVII. Geological formations in Lyon [illegible]

Drawn by A. J. Smith.

DAKOTA SANDSTONE IN WASHINGTON COUNTY.

BY H. W. CHARLES, WASHINGTON, KAN.

Read before the Academy December 28, 1900.

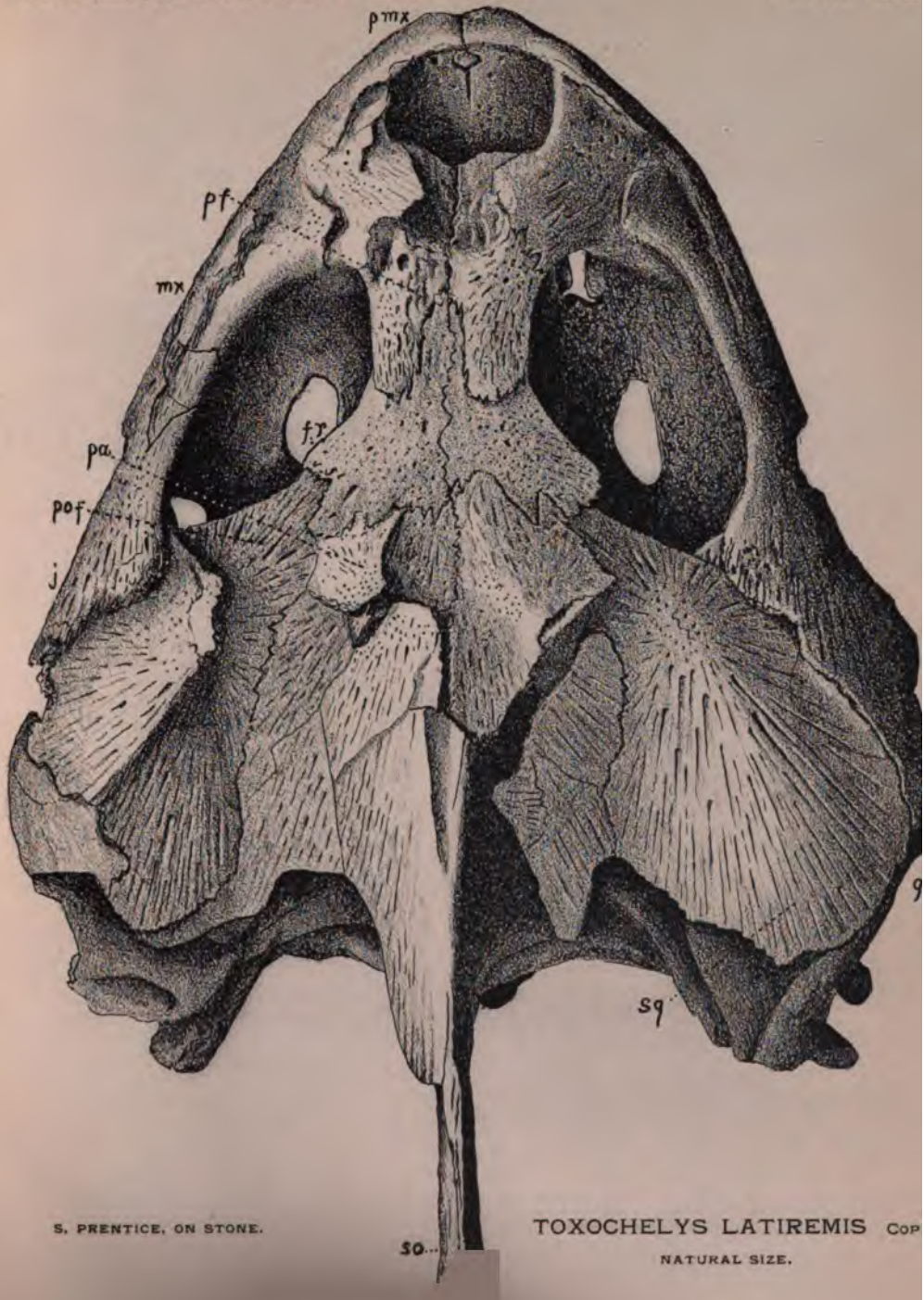
The Dakota formation, extending diagonally across the county, rests unconformably upon the Permian limestone. This is true throughout the Dakota area, so far as can be determined from the numerous exposures along its eastern border. Several well-defined contacts have been discovered, a most interesting one being on the farm of Mr. John Sage, in Farmington township. Another, that apparently shows thin transitional strata, is located about one mile south of Bond's mill, in Charleston township. The upper surface of the underlying Permian is generally level, although in some localities there are evidences of a difference of level extending over limited areas.

The Dakota, in general, shows the typical structure in its exposures. In several localities there are outcrops of massive sandstone, notably on the farm of Mr. Sage, above referred to, and also on the farm of Mr. F. J. Weakly, in Washington township. In most localities, however, the exposures consist of irregular masses cropping out above the disintegrated material of the same formation, mingled with the overlying drift or loess. Evidences of glacial deposits may be found throughout almost all the Dakota area of the county.

In the northeastern part of the county the rocks of this formation are dark in color and very hard, while in the central and western portions they are not so compact and disintegrate rapidly where exposed. In Highland township the structure is characteristic, but the color is much lighter than in other sections of the county.

In the western part of the county the overlying Benton limestone is separated from the sandstone in a few places by layers of lignite, in some places two or three feet in thickness.

The characteristic fossils of this formation are found in a few localities, though not generally distributed throughout the county. A few well-defined specimens have been found on the farms of Mr. Lavering and Mr. Carnahan, in Washington township. About one mile south of Ash Creek schoolhouse, on the farm of Mr. Weakly, several specimens were found in a bluish shale of the Dakota formation. About one and one-half miles southwest of Day, and over an area extending into Clay county, some very fine specimens have been found by persons residing in that locality. By far the most interesting area of fossils, and the one that suggested the writing of this paper, is in the vicinity of Bond's mill, in Charleston township. Here was found a field hitherto unexplored, and one which furnishes some interesting material for the student of paleobotany. A short distance south and southeast of Bond's mill, on the high sandstone bluffs, and scattered over the surface of the ground, several thousand specimens were found, at first in company with Prof. C. N. Gould, at that time connected with the State University of Nebraska, and later in connection with my work in geology in the high school of this city. Most of these specimens were sent to the University of Nebraska, where they were examined by Professor Gould. Representatives of the *Sassafras*, *Platanus* and *Protophyllum* were identified. Many belonged to the well-known species of these genera, but there are evidently several new species awaiting identification. Some of these forms are apparently transitional, and may furnish evidence of the close relationship of the *Sassafras* and *Platanus*.



S. PRENTICE, ON STONE.

TOXOCHELYS LATIREMIS Cop

NATURAL SIZE.

A NEW TURTLE FROM THE KANSAS CRETACEOUS.

BY S. W. WILLISTON, UNIVERSITY OF KANSAS, LAWRENCE.

Read before the Academy, December 28, 1900.

Porthochelys laticeps, gen. et sp. nov.

SKULL. The palatal surface of the maxillæ is very shallowly concave, and somewhat inclined inward; it is very broad, especially posteriorly. The alveolar or cutting edge is remarkably deep, especially posteriorly, decreasing to a little more than half the width at the front part. This whole structure is in striking contrast to the same parts in *Toxochelys*, where the vertical portion decreases in width posteriorly. On the posterior third the inner margin of the palatal surface is roughened, where it joins, for most of the distance, the pterygoid processes. This roughened line is continued on the palatines to their junction with the vomer. At the base of the vertical portion, which stands nearly at right angles to the other surface, there are some small, nutrient foramina anteriorly. The external surface of the bone is very broad, strongly convex near the lower margin, and much broadened posteriorly.

The premaxillaries in front are deeper than wide, strongly convex from above downward, and receding below to the sharp alveolar border. In the nasal opening the margin is rounded and deeply concave in each bone, the two forming a pointed, median tubercle. The sutures with the maxillæ are parallel throughout. On the buccal surface the vertical and palatal parts are nearly at right angles to each other, the latter a little the broader. Posteriorly their union with the vomer forms a concave line, just back of which there are some small palatine foramina. There is but slight indication of the fossa that is well marked in *Toxochelys latiremis*.

The prefrontals are thick and strong, the two together nearly square in outline or a little broader than long. In the nares the two project into a rounded, obtuse angle. They form the upper margin only of the nares, the maxillary suture evidently running from near the angle of the orbit to the angle of the nares. Posteriorly they unite with the frontals by a straight transverse suture before the middle of the orbit.

The frontals are deeply marked with grooves, as are the prefrontals. Their orbital margins are thin and nearly evenly concave in outline, extending outward about one-third of the width of the orbit. About five millimeters back of the orbits they join the parietals in a nearly straight transverse suture. Below, the two bones are strongly thickened in the middle to include the rhinencephalic groove.

The parietals are incomplete posteriorly in the described specimen. They have the same rugose markings as the two preceding bones, and are strongly arched. The parieto-postfrontal suture joins the angle of the parieto-frontal and fronto-postfrontal sutures, and is directed obliquely outwards and backwards.

The postfrontals, or postorbito-frontals, connect the frontal internally with the jugals externally, and form the thin posterior margin of the orbits, as in *Toxochelys*. The union of the jugal is much the same as in *Toxochelys*. The suture in the outer part of the orbital fossa runs straight forward nearly parallel with the palatine suture and with the median line of the skull to the orbital margin, and then turns backward irregularly on the outer surface. The union is strong and massive. The bone is broad and convex externally. Posteriorly, it joins the quadrato-jugal in an oblique suture. The lower border is thin and concave.

The vomer is stout, broad and concave anteriorly; laterally, the anterior expanded portion joins the maxillæ in a rugose suture, expanding backward to join the anterior end of the palatines, as in *Toxochelys*, excluding the maxillæ from the narial border. At the beginning of the narial opening the bone rapidly narrows to less than half of its greatest width, and gently widens to its union with the pterygoids. Between the nares the bone forms a stout, narrow ridge, which becomes nearly obsolete at its junction with the pterygoids.

The palatines are broadly connected with the maxillæ. From the rugose ridge already mentioned, continuing the border of the maxilla forward, the bone turns upward, and is thinner, forming the shallow concave groove of the nares. They join the vomer broadly in a nearly straight suture, and posteriorly the pterygoids on the outer part of the transverse suture.

The pterygoids have the median suture nearly obliterated. They are grooved shallowly in the middle. Laterally they send out a broad, ectopterygoid process, for union with the maxillæ and jugals. Near the middle posteriorly there is a vertical flattened surface to abut against the mandibles. The large, oval, palatine foramen is enclosed nearly wholly between these two bones, the free maxillary border showing only for two or three millimeters. Posteriorly the pterygoids join the quadrates by a flattened process; in the middle by a V-shaped suture, the basisphenoid. Near the end of the arms of the V there is a small foramen on each side.

The basisphenoid shows a small, triangular, nearly smooth surface between the pterygoids and basioccipital.

The basioccipital surface forms a shallow fossa. The occipital condyle is bipartite.

The external nares are much broader than high; their sides, formed by the maxillæ, are nearly parallel; the lower border, formed by the premaxillaries, is biconcave, with a median tubercle; the upper border, formed by the prefrontals, has a strong convexity from near the rounded angles; on the floor a narrow, well-marked groove runs from each palatine foramen forward nearly to the free margin.

The orbits are obliquely ovate in outline and look obliquely upward, outward, and forward. On the anterior part below, the opening of the nares is marked by a sharp ridge in the palatines; under the posterior part is seen the larger part of the palatine foramina.

The mandibles are remarkable for their stoutness and breadth. The alveolar surface is shallowly concave, longitudinally and transversely, and narrow at the symphysis, which is marked by a prominent rugose ridge. Posteriorly the surface rises very high into the coronary process, beyond which the specimen described is for the most part wanting. Below, the part described forms a broad, gently convex surface, marked by numerous small foramina. Internally there is a well-marked groove below the thinned inner border of the alveolar surface. In the middle, in front, the surface forms a rather broad, trough-like concavity. The symphysis is elongate.

As a whole, the skull is remarkable for its broad, strongly convex form, its extremely deep alveolar margin of the maxillæ, its rostral protuberance, and the broad, flattened and strong maxillæ, together with the strong venous markings of its surface. While the posterior part of the described skull is injured, it was undoubtedly roofed over, as in *Toxochelys*. While the general relations of the bones are nearly as in *Toxochelys*, the proportions and forms of the different parts are very different, all indicating distinctly different habits.

CARAPACE. About three-fifths of the carapace is preserved. In the drawing

Fig. 1.

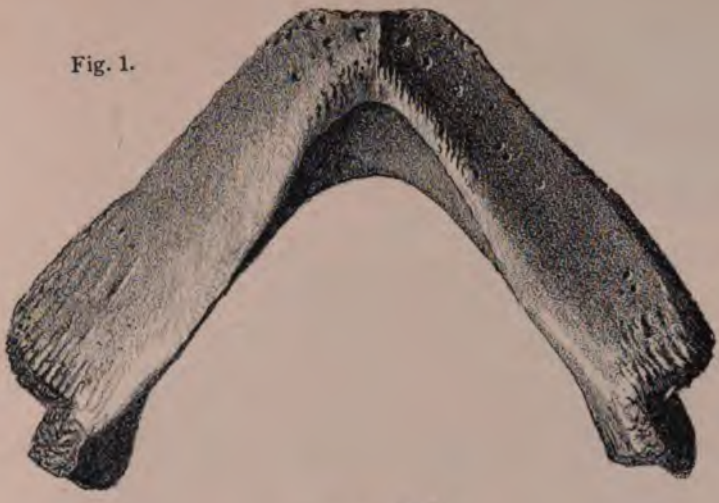
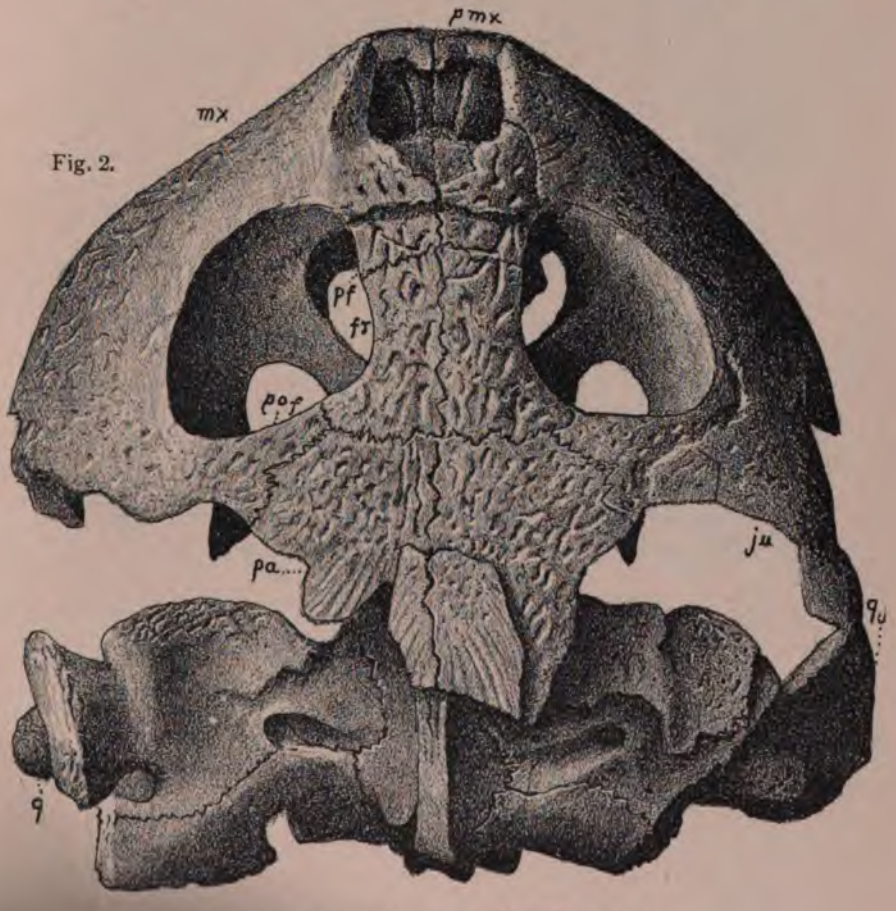


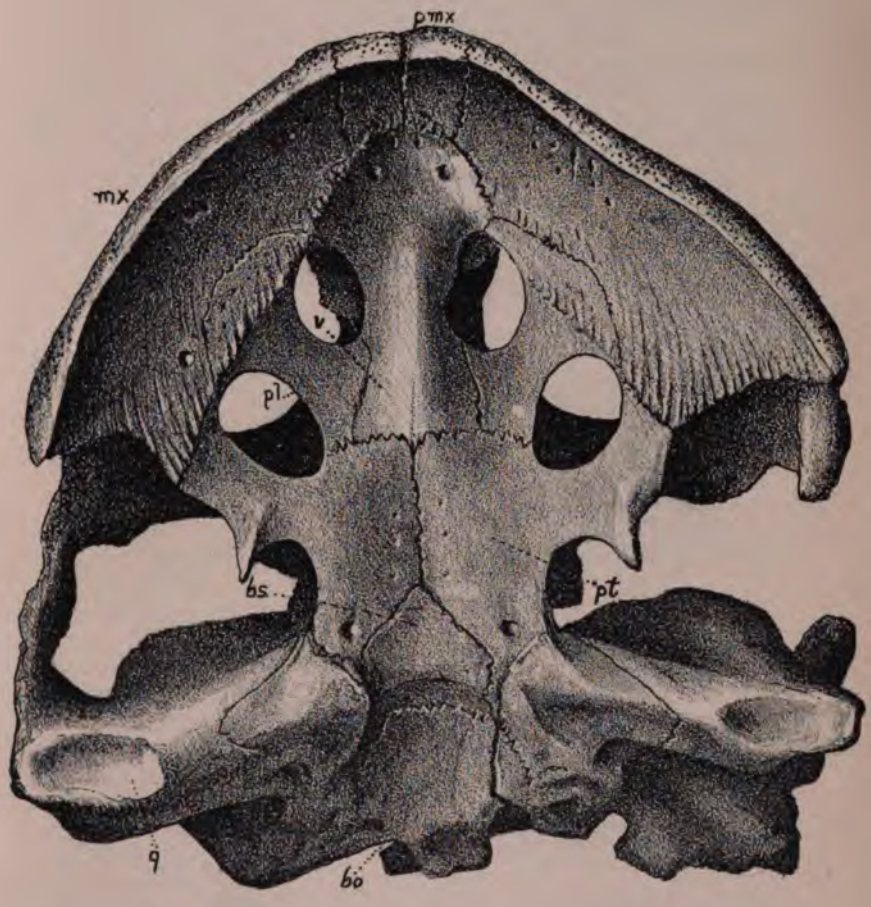
Fig. 2.



...THOCHELYS LATICEPS WILL.

NATURAL SIZE.

Fig. 2. Cranium.



PORTHOCHELYS LATICEPS WILL.

NATURAL SIZE.

the middle portion of the right side has been restored from the left. In shape the carapace is broad and but little pointed posteriorly. As preserved it is but slightly convex, though doubtless more so in life. The surface is smooth, except where marked by the shield grooves. It differs from other American Cretaceous turtles of allied structure in the almost complete ossification. Except in the first pleural, there is between each and the peripheral a small, rounded or oval vacuity, with smooth, rounded, thickened margins. The margins, however, are so closely pressed down upon the peripherals that their precise nature is not easily made out.

The neurals are narrow throughout; they are smooth, without protuberance or elevation, and they show no trace for attachment to the vertebræ below. The second, third, and fourth, all that are preserved anteriorly, articulate on the anterior lateral margin angularly with the preceding pleurals, behind which the lateral borders are nearly straight and parallel. The last neural and a part of the one preceding it are preserved; they are narrower than the anterior ones. There are two post neurals; the first is large and triangular in shape, with the anterior apex truncated for the eighth neural. The second is of about the same size as the first, and in the shape of a regular trapezium, articulating broadly behind with the pygal.

The pleurals are of the usual number—eight. The first is relatively small, joining in its full length the first and second peripherals, and by its apex the third; the second pleural is, perhaps, the broadest of all, and joins the third, the whole of the fourth, and a small part of the fifth peripherals; the third pleural, nearly as broad, joins the most of the fifth and a small portion of the sixth peripherals; the fourth pleural, also broad, joins the most of the sixth and more than half of seventh; the fifth pleural, the narrowest, especially proximally, joins a part of the seventh and more than half of the eighth peripherals; the sixth pleural, a little broader than the fifth, joins for about an equal extent the eighth and ninth peripherals; the seventh pleural has the larger part of its distal border joined to the ninth peripheral and a lesser portion to the tenth; the eighth pleural articulates almost exclusively with the tenth, just touching the eleventh.

The peripherals, of the usual number, are narrow anteriorly, broad and massive posteriorly. On the posterior part, near the middle of each bone, where the shield suture reaches the thin margin, there is a marked angulation, with the intervening borders concave; these angularities are slight or none at all anteriorly. The nuchal bone is, unfortunately, largely missing, so that it is now impossible to say whether or not there was an articulation with the cervical vertebræ so characteristic of the sea turtles. The pygal is small; its borders are thin and placed at an obtuse angle with each other, and with a semicircular notch in the middle, where they meet.

The shields are well indicated by grooves, and are of the usual number and arrangement, as in *Chelone* or *Chelydra*. The vertebrals are relatively small. The cervical and caudal are of considerable size. The first lateral is relatively small. There are four laterals. The pygal shield is double, making twenty-five as the entire number.

Of the plastron, the hyoplastron and xiphiplastron are complete or nearly so; the hypoplastron lacks the outer part on both sides; and of the epiplastron, only a small part, suturally united to the hyoplastron, is preserved. In the drawing, the elements of the two sides are separated as far as the carapace would permit. In all probability, if not certainty, however, the bones of the two sides interlock in the middle, leaving only a median fontanel, of moderate size, and a slender one between the xiphiplastra.

The union between the hyo- and hypoplastra is long and stout, the bones here being ten or twelve millimeters in thickness and the suture a close one. The other margins are thinned, and the denticulations are not long. The suture of the elongate and thin xiphiplastra with the hypoplastra is oblique and irregular, but firm. Of the other elements of the skeleton not many are preserved. A single biconcave cervical vertebra and a concavo-convex centrum, in their crushed condition, present no distinguishable differences from the neck vertebræ of *Toxochelys*.

A proximal portion of the scapula and a claw likewise offer no tangible differences from the same bones of *Toxochelys*.

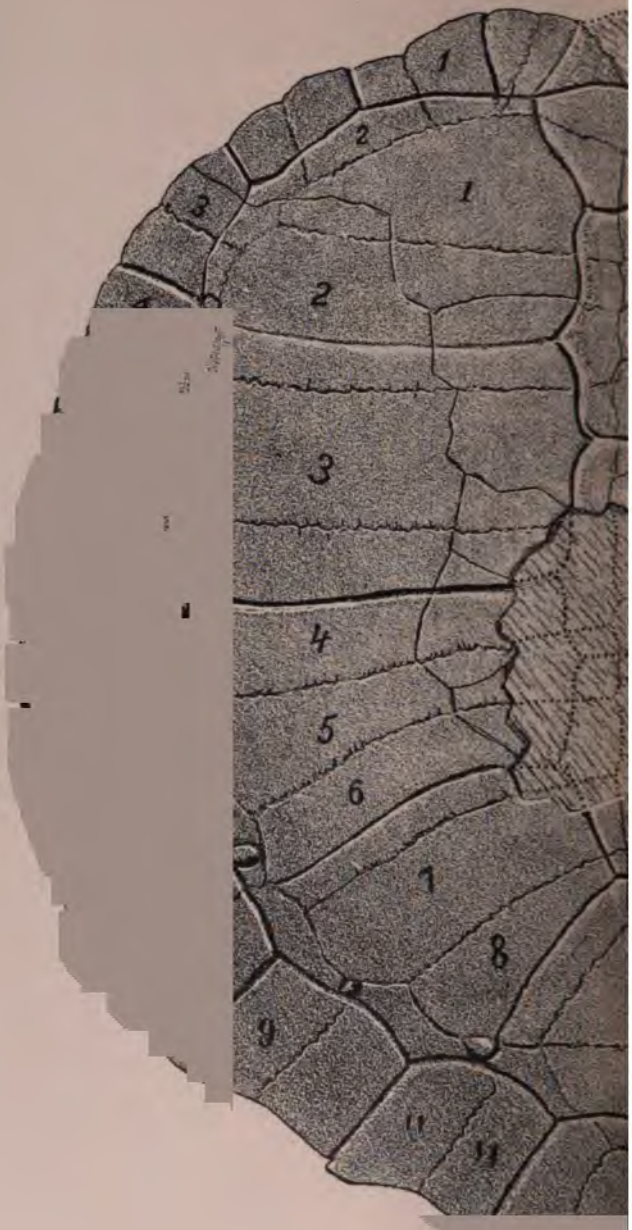
The humerus preserved unfortunately lacks most of its ulnar process. The articulating surface is in the shape of a large oval directed toward the dorsal side. The radial process is stout and prominent, directed ventrally, with a deep depression on its inner side and rugose markings on its external surface. The shaft is considerably constricted below the expanded part and moderately dilated distally, and is strongly curved. There is a well-marked ectepicondylar groove near the external border distally. The bone is flattened throughout, doubtlessly largely of post-mortem origin.

The distal part of an arm or leg bone, probably the radius, is present. It is much flattened and curved; the articular border transverse.

The relationships of *Porthochelys* are clearly with *Toxochelys latiremis*, which certainly should be included in the same family. Of *T. latiremis* almost nothing is known concerning the carapace and plastron. I suspect that when the carapace of this form is found it may have a fully coossified carapace, as in *Porthochelys*. From *Toxochelys serrifer*, of which the carapace is pretty well known, the differences are obvious in the incomplete ossification, the serration of the neurals, the shape of the pygal, etc. This species is the most common of the testudinates of the Kansas Cretaceous; and I believe that when the type of the genus *Toxochelys* is better known *T. serrifer* will be relegated to another genus. The generic differences from *Toxochelys* must then, for the present, be based upon cranial characters—these, I believe, are amply sufficient—in the structure of the mandible, the maxilla and the strong alveolar border, the shape of the prefrontals, frontals, jugals, etc.

From other Cretaceous turtles, certainly the American ones, differences are obvious. From *Osteopygis*, *Lytoloma* (*Euclastes*), *Peritresius*, *Catapleura*, *Plastomenus*, the ossification of the carapace, smoothness of the bones, shape of the skull, etc., will distinguish. The skull shows considerable resemblance in shape to that of *Bothremys*, but differs materially in the structure of the maxillæ.

In what family of turtles this genus, as well as *Toxochelys*, should be placed is yet a matter of uncertainty. Hay and Case are both inclined to locate *Toxochelys* with the Cheloniidæ. In the present genus, the ossification of the carapace, the more complete ossification of the plastron, the presence of large palatine foramina, the anterior location of the internal nares and the structure of the humerus are differences from the sea turtles that should not be overlooked. It is true that in old individuals of the sea turtles, especially of *Thalassochelys*, the carapace may become ossified throughout. Nevertheless, the high degree of ossification of both the carapace and plastron in this form indicates a less high degree of specialization to aquatic conditions, and a greater resemblance to *Chelydra* and its allied forms. I believe that when the limbs of individuals of this genus, as also of *Toxochelys*, are better known, they will present less of the flipper-like structure than is now believed to be the case.



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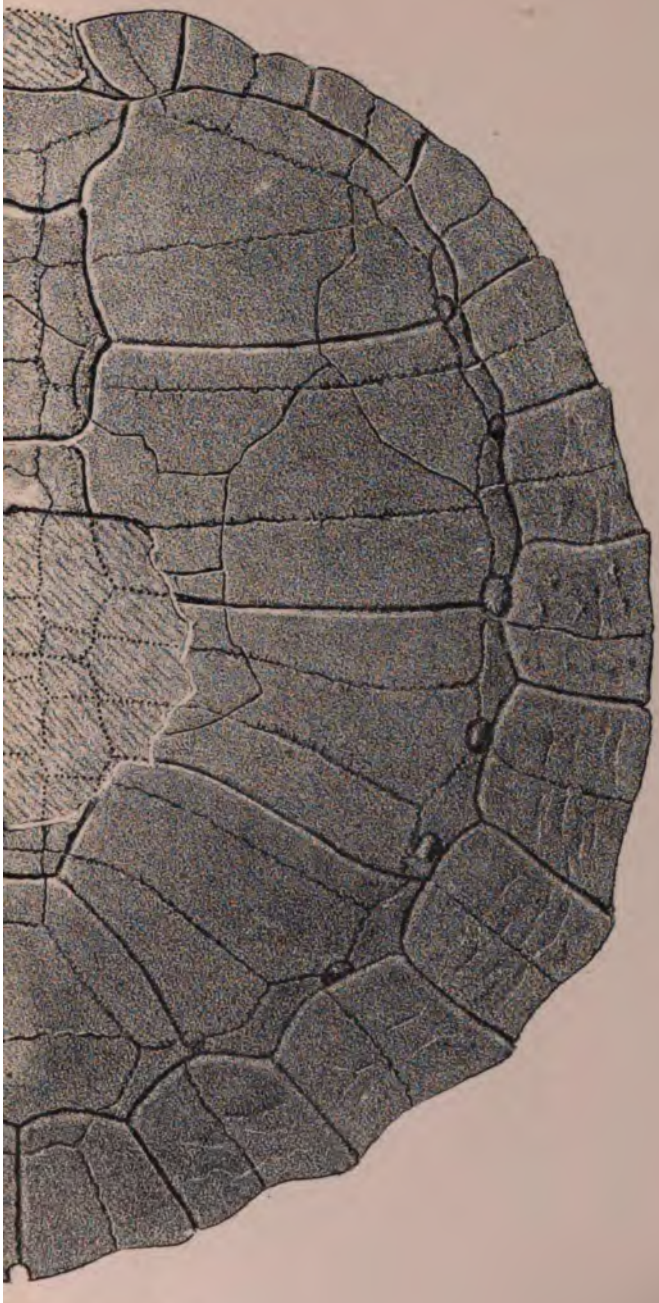

YS LATICEPS WILL.

is natural size.

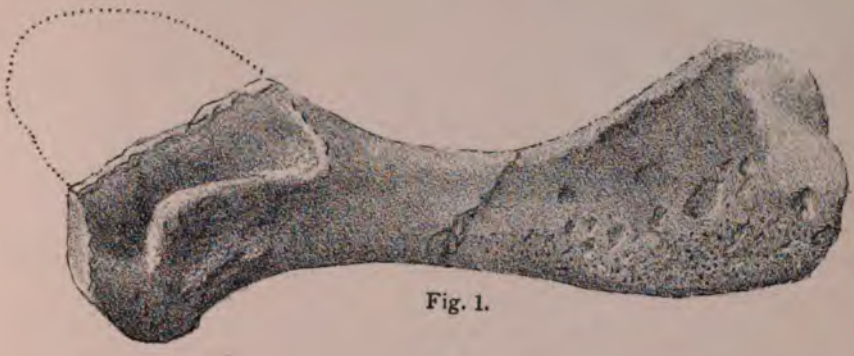

Fig. 1.

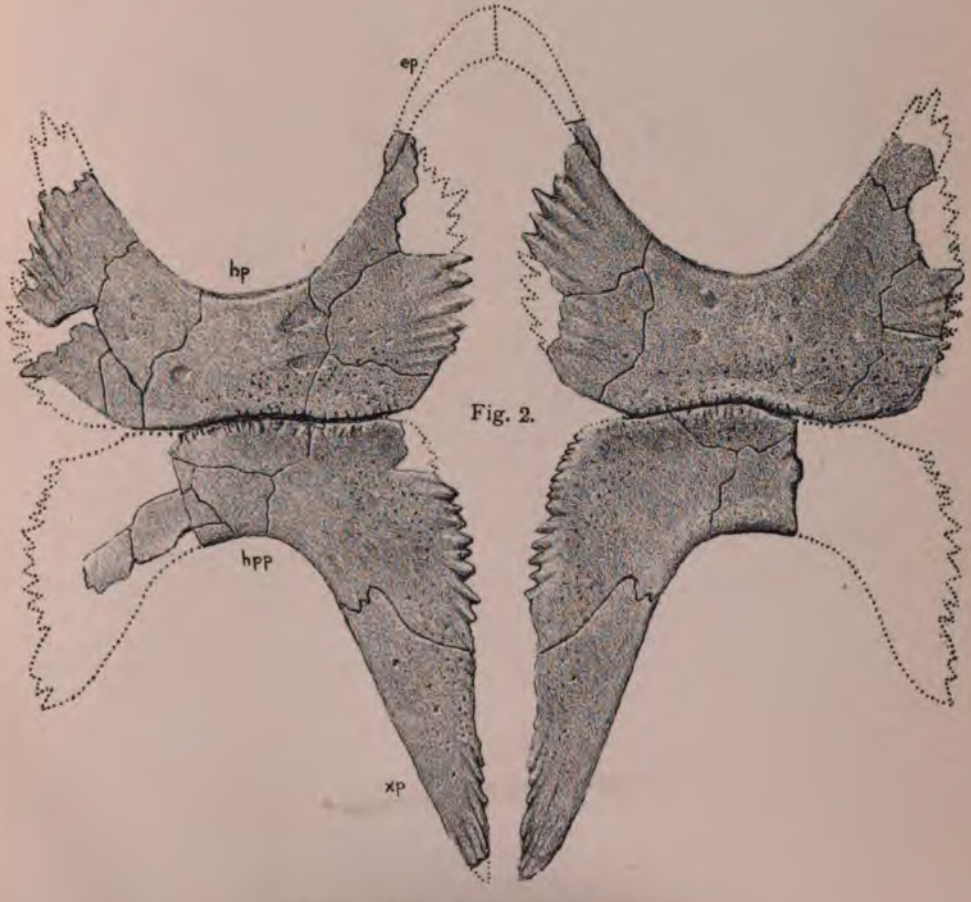

Fig. 2.

PORTHOCHELYS LATICEPS WILL.

Fig. 1. Ventral view of

Fig 2

d size.

Certainly the large size of the radial process, its position on the ventral side of the bone, the strong curvature of the shaft of the bone, and its less expansion distally, are all characters inconsistent with the Cheloniidæ. (See Wieland, Am. Jour. Sci., 9: 413, 1900.)

The remarkably complete specimen upon which this genus and species are based was collected by Mr. E. H. Sellards, of the paleontological department of the university, on the Saline river, in Trego county, the past summer. I wish also to express my thanks to Prof. J. T. Shearer, of Wa Keeney, for kind assistance in the collection of the specimen.

For the sake of comparison, I give a figure, natural size, of the upper view of *Toxochelys latiremis*, made from an unusually well-preserved specimen in the university museum, collected by Mr. H. T. Martin, in Logan county, Kansas.

EXPLANATION OF PLATES.

The following explanation applies to the first three plates: *pmx*, premaxillary; *mx*, maxillary; *pf*, prefrontal; *fr*, frontal; *pof*, postorbito-frontal; *pa*, parietal; *j* or *ju*, jugal; *q*, quadrate: *v*, vomer; *pl*, palatine; *pt*, pterygoid; *bs*, basisphenoid; *bo*, basioccipital; *qj*, quadratojugal.

Plate XVIII. *Toxochelys latiremis* Cope, natural size.

" XIX. *Porthochelys laticeps* Will., natural size. Fig. 1, dentary; fig. 2, cranium.

" XX. *Porthochelys laticeps* Will., natural size.

" XIX. *Porthochelys laticeps* Will., upper view of carapace, two-ninths natural size.

" XXII. *Porthochelys laticeps* Will. Fig. 1, ventral view of right humerus, three-fourths natural size; fig. 2, plastron, two-ninths natural size: *e*, epiplastron; *hp*, hyoplastron; *hpp*, hypoplastron; *xp*, xiphiplastron.

GEOLOGY OF THE GLASS MOUNTAINS OF WESTERN OKLAHOMA.

BY MARK WHITE, SOUTHWEST KANSAS COLLEGE, WINFIELD.

Read before the Academy, at McPherson, December 28, 1899.

During the summer of 1899, the author, in company with his brother, Mr. Paul J. White, made a hasty trip to the Glass mountains. During this trip the material for this paper was collected. The author does not claim for this paper a high grade of science work, but a mere sketch of the Glass mountains, and of the geological formation found there.

From the northeast, as first viewed by us, the Glass mountains may be seen for about thirty miles. They are situated in the southwest to central south part of Woods county, Oklahoma, and cover a territory extending south from the Cimarron river for a distance of six or eight miles and in width four or five miles.

Strictly speaking, the Glass mountains are hardly worthy of the name of mountains, as evidently they are but what is left by erosion of a portion of the Upper Cretaceous. The first peak to which we came from the east, and which is called by the cattlemen "The North Peak," is about ten miles southwest of Cleo, Woods county, Oklahoma. We crossed the Cimarron river by fording at Cleo. The stretch of country from this place to the mountains is a level alkali plain, with but little vegetation except mesquit and sage-brush. The plain reaches to the very foot of the mound, which is about 200 feet in altitude and almost circular. To the south of this mountain is one covering much more space, but it is

not so regular in form, it being much longer than broad. To the west we can see nothing but similar mountains. Being limited for time, we visited but the two mountains.

The following is a section made from the "North Peak," on the east slope:

No.			
37.	On the summit of the mountain soil is found five or six feet in thickness, and in this were growing a dozen or more species of Western flora	+6	196
36.	Under the soil is a cap of white gypsum rock which is found in both of the mountains visited, and probably accounts for the erosion having taken place as it has	10	186
35.	Blue clays	2	184
34.	Red clays, with layers of gypsum and sandstone	10	174
33.	Clay and gypsum	2	172
32.	Clayish, red sandstone	10	162
31.	Red clay, containing stripes of blue	6	156
30.	Shaly sandstone	2	154
29.	Red clay	5	149
28.	Shaly sandstone	2	147
27.	Red clay, containing gypsum	30	117
26.	Gypsum rock	1	116
25.	Red clay, containing gypsum	30	86
24.	Gypsum in thin layer.		
23.	Red clay	5	81
22.	Gypsum like No. 24.		
21.	Red clay	3	78
20.	Blue clay	2	76
19.	Red clay containing gypsum	6	70
18.	Thin layer of gypsum.		
17.	Red clay	4	66
16.	Gypsum like No. 18.		
15.	Red clay	4	62
14.	Blue clay striped with red	2	60
13.	Red clay	6	54
12.	Thin layer of gypsum.		
11.	Blue clay, blending with red	4	50
10.	Gypsum layer, like No. 12.		
9.	Red clay	10	40
8.	Gypsum like No. 12.		
7.	Red clay	5	35
6.	Gypsum like No. 12.		
5.	Red clay	5	30
4.	Gypsum like No. 12.		
3.	Red clay	4	26
2.	Blue clay	2	24
1.	Red clay and covered slope of the plain	+40	0

Comparing this section with sections made by Professor Prosser in the "Cretaceous-Comanche Series of Kansas,"* from the Medicine Lodge regions, I conclude that the formation is very similar to that found about Medicine Lodge, Kan.

KANSAS MINES AND MINERALS.

BY G. P. GRIMSLEY, WASHBURN COLLEGE, TOPEKA.

A lecture delivered before the Academy, at Topeka, December 28, 1900.

Industry and painstaking patience have changed the grass-covered, open prairies of Kansas into a land of waving wheat and corn, which yield their annual harvests of golden grain. Fertile soil, rain and bright sunshine have in this area solved the problem of the ancient alchemists and have converted earth into gold. Here the cow, steer, hog and "helpful hen" have found a congenial home, and have added their quota to the wealth of the state, helping to usher in the reign of prosperity for Kansas. This surface wealth is clearly seen, and attracts the attention of the stranger within our gates as well as the home-loving native.

The agricultural story is told over and over again, always with added interest; but the wealth below the reach of the light of day, gathered by the steel fingers of the pick and drill—the hidden treasures—is too much overlooked, even by our own citizens; so it is no wonder that this storehouse below the soil is almost an unknown factor to the people outside our borders.

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*Univ. Geol. Surv. of Kansas, vol. II.

Gold and silver, like the prophets of old, we have none; but we do possess mineral in abundance, which is readily exchanged for these precious metals which the world so zealously strives to obtain.

Geologists and explorers have talked and written about Kansas from early days. Fossils and rock strata have been described by them in learned terms, often unintelligible to the masses, but yet holding a dignified position in the annals of science.

Lewis and Clarke, those intrepid explorers, early in our century made their perilous way to our country's western border. As they passed across the plains of Kansas they noted the occurrence of limestone, clay, and coal; but it was not until the dark and stormy days of the war of emancipation had closed that an organized survey of our mineral resources was made.

In 1864 Prof. B. F. Mudge began his labors as director of the geological survey of Kansas, and published a report on the coal and salt deposits. The survey was maintained only two years, and it was not resurrected until 1895, when the present University Geological Survey was organized.

In the long interval between the surveys individual geologists and prospectors advanced the knowledge and development of the state's mineral deposits. It was during this period that the Kansas Academy of Science was of special value to our state in fostering the scientific spirit and furnishing a medium of publication. These reports and those of the state survey furnish accurate and valuable descriptions of our mines and minerals.

It is fitting that, on the dawn of this coming century, we pause in our routine of work and look back over the past history of our mineral development and take an invoice of our present resources. Only a score of years ago three minerals were mined in Kansas: coal, building stone, and some zinc, with a value of about one million dollars. To-day, in addition, we have salt, gypsum, oil, gas, mineral water, clay, natural cement rock, Portland cement materials, with a value of nearly twenty million dollars a year, or, with the Argentine smelter, of thirty-nine million dollars. Many of these products are in the infancy of their development, and none is worked to its fullest capacity. New industries have started this year, and a number have been planned for the coming year. Kansas is on the up grade in mineral development.

COAL.

Coal and iron are the foundation stones upon which the greatest industrial progress of the nineteenth century rests. Not until the seventeenth century did England and Europe realize the value of this rock fuel, and about a century later coal was mined near Pittsburg, Pa.

In Kansas coal was about the first deposit to attract attention, and it is now our most important mineral. Thirty-five years ago the settlers of Cherokee county warded off the chilly blasts of winter by fires of coal taken from the neighboring creek banks. The largest hoisting shaft in the state, and probably in this country, is found at the present time at Chicopee, in Crawford county, which is the banner coal county of the state, sending out, with Cherokee, over eighty per cent. of the total coal supply which comes from twenty-nine counties. Ninety-eight per cent. comes from six counties: Cherokee, Crawford, Bourbon, Leavenworth, Osage, and Labette. In southeastern Kansas there are about thirty separate coal-veins, ranging from eight inches to nearly four feet in thickness. There are 250 coal-mines in the state, with a depth of a few feet to 720 feet, at Leavenworth. Two thousand two hundred feet above the base of the lower coals comes the Osage coal, accidentally discovered in 1869 in digging a well n[illegible] mined at various places along the Santa Fe railroad.

Above this horizon no coal in paying quantities is found in the Coal Measures of the state.

The Coal Measure rocks, on account of their varied character, often form scenery of great beauty. Compare, for example, the view of the Ohio measures with a view in the Coal Measures of this county, a scene on the Shunganunga.

The area covered by Coal Measure rocks in Kansas is 20,000 square miles. The state survey has estimated that, with all allowances, 40,000 square miles are coal producing, with an average of two and one-half feet of coal, which would yield perhaps eight billion tons. At the present rate of mining, this would last 2000 years, and, at the average price for the past ten years, would have a value of twelve billion dollars. It is difficult for the mind to grasp the meaning of such figures, and yet this is only one of our minerals.

NATURAL GAS.

Just twenty years ago the industrial world awoke to the fact that another form of stored fuel existed in the deep recesses of earth, and the natural gas excitement was ushered in, reaching its height about 1886. The northern Ohio farm lands took on the aspect of mining camps, and small villages grew rapidly into manufacturing cities. Coal had a new rival, and the wheels of industry were now to be run with a more convenient fuel. Blind folly decreed that the supply was inexhaustible, and the flaming street torches marked the gas cities by day and lighted the race-tracks with a circle of fire by night.

Some prophetic sages predicted that disaster would follow when wanton people were destroying the fuel which a higher power had concealed for the final destruction of this world; and the wasteful extravagance did cause disaster, but in another way. To-day, in many of these districts of the East, the gas-pipes are rusting in the streets; the race-tracks are dark and deserted at night; the dark-faced fireman again stands before the furnace door; and the troublesome coal bills again loom up before the weary eyes of the man of the house, who now has to carry the full coal pail. The lesson was learned, often too late, that this valuable fuel was limited, and that its day was brief even where carefully used.

We have in Kansas some valuable gas and oil fields, and the sad experience in the East has had its influence; so that there is not such reckless waste, but the waste is there. It is to be feared that some future day our cities will regret the burning house and street lamps day and night, as one sees in our gas belt. It is stated that it is cheaper to burn the gas than to buy matches, which represents poor economy. Meters are never used, and the charges are made by the month.

The Iola gas field has a length of ten miles and a width of at least four miles, with a total capacity at the present time of 200,000,000 cubic feet in twenty-four hours, which would be equivalent to nearly 10,000 tons of coal a day, or equal to the total coal production of the state. It is very difficult to determine how much gas is used a day for all purposes in the Iola field; but it certainly is not far from 17,000,000 cubic feet; so there is a heavy reserve not disturbed. These wells are drilled to a depth of 815 and 920 feet and the rock pressure of the gas, as measured by a gauge, is 315 to 325 pounds to the square inch. This is the motive power which forces the gas out of the wells and through the pipes. The drills cannot be driven more than fifteen or eighteen feet into the gas sand, for the pressure is so great that the tools, though weighing over a half ton, will not sink. As the gas escapes from the open well the roar is deafening, and can be heard for miles.

The Coffeyville gas field has been developed over an area of seven by three miles, and of the fifty-four wells drilled forty-four are productive in greater or less amount. The Cherryvale field is being rapidly developed and new industries

are starting here as well as at Chanute. Other important fields are found at Independence, Paola, Chetopa, and Erie. This whole area, estimated at nearly 9000 square miles, with its excellent railroad facilities, promises to become an important manufacturing district.

As to the duration of this supply very little can be said; the newspaper comments from time to time about the gas rapidly giving out in these areas have very little foundation. In Iola wells which have been used constantly for the past six years have lost ten pounds pressure, but when closed for a few days regain part of this amount. With this loss they still have 300 pounds pressure, and a large smelter would only require about eight ounces a day. With care, these fields ought to last for a long time, and it is safe to say that there will be gas in Kansas when the eastern fields have been abandoned. Our state ranks about fourth among fourteen gas states in value of gas utilized, but only a very small fraction of the available supply is yet used. During the past year some very wealthy companies have obtained control of the fields and development on a large scale will soon follow.

OIL, OR PETROLEUM.

One of the latest mineral industries to be developed in the state is that of coal-oil. Its discovery, however, dates back over thirty-five years, to the early days of Kansas. The "Pike's Peak or bust" gold hunter and other "Westward, ho!" emigrants camped in Johnson county, and bought for wagon grease the heavy, dark oil which was skimmed from the surface of a well dug for water. In 1860 the Oil creek, Pennsylvania, excitement reached its height, and a new industry was opened in the United States, which has served as a basis for immense fortunes and has resulted in the formation of America's greatest trust. In 1871 the wave of this excitement reached Kansas, and a well was drilled at Paola, resulting in the discovery of gas, but no oil in paying quantity. Twenty years later, at Independence, wells were sunk to a depth of 884 feet, resulting in the discovery of a large oil field. The developed oil field is in Wilson and Neosho counties, where a million dollars has been expended and seventy oil wells drilled, near Neodesha, Humboldt, Thayer, Sedan, Guilford, and Buffalo, with a daily flow of ten to fifty barrels each. The oil is carried in pipe lines to a large oil refinery, at Neodesha, which has been in operation for three years. The field is owned by the Standard Oil Company, and only a small amount of the supply is used at the present time; but the state holds eighth rank among fourteen districts of the United States.

LEAD AND ZINC.

The second mineral in importance in Kansas is zinc; and as lead is so closely associated with it, the two are considered together. The deposits in Cherokee county were discovered in 1868, then forgotten, and rediscovered in digging a well in 1876. This discovery was followed by great excitement. Thousands of people flocked in, fortunes were made and lost, and the mining camps grew into the cities of Galena and Empire City, under which extend the tunnels of many mines, and the hoisting shafts are dotted through the towns. Few men in those days even suspected that Kansas was soon to become the second state in the union in zinc smelting, and that the markets of the world would be controlled, to a large extent, by those shafts in the Short Creek valley.

The lead- and zinc-producing area of Kansas is not large in surface extent, covering about sixty square miles in the southeastern corner of the state, in Cherokee county, and near the Missouri line. The main mines are within the towns of Galena and Empire City, where the ores, mixed with white- and dark-colored flints, are obtained in shafts 50 to 120 feet deep. In 1878, 143 tons of lead ore

were removed, but no zinc. In 1899, 6700 tons of lead and over 64,000 tons of zinc ore were mined in this area. Most of the lead ore is smelted outside the state, while the zinc ore was smelted at Pittsburg, Weir City, and Girard; but now nearly all of it is smelted within the gas belt, at Iola, Gas City, and Cherryvale. The great smelting company of the Southwest was the Cherokee-Lanyon company, whose Pittsburg works are now being torn down, as the company has been consolidated with others at Iola under the name of Lanyon Zinc Company. In and around Iola there are 23 blocks, of 600 retorts each, for the smelting of zinc. These works are the largest in the United States, and will soon be the largest in the world. The daily production of metallic zinc, or spelter, as it is called, is nearly 200 tons, which requires 400 tons of ore, and, if gas was not used, would consume about 1200 tons of coal. This represents nearly one-half of the total production of the United States. Among the states of the union, Kansas stands a close second to Illinois in production of metallic zinc.

SALT.

One of the necessities of life is salt, the record of whose discovery is lost in antiquity. Nature has dealt kindly in its distribution, for it is found almost everywhere over the world and in rocks of all geological ages. In the early days of Kansas, salt was obtained by the evaporation in kettles of water from the salt marshes located near the borders of the present developed salt area in Republic, Cloud and Jewell counties. The first salt well was used in 1867, at Solomon City, and the brine evaporated by the sun's heat. These Solomon wells are in use today, and this is the only locality in the state where salt is obtained by the solar process.

Out of the wreck of the disastrous boom excitement of 1887–'88 some good results came to Kansas. One of these was the development of the salt industry at Lyons, Hutchinson, Sterling, Kanopolis, and Kingman. At Lyons prospect holes were drilled for oil and gas, resulting in the discovery of 300 feet of salt, at a depth of 700 feet. This is now mined at Kanopolis, Lyons, and Kingman. The quality is shown by analysis be 99.93 per cent. pure. At Hutchinson and Sterling, salt is obtained from brine, in wells 700 feet deep. The brine is evaporated by artificial heat, in pans, either by means of direct heat or by steam. The daily capacity of these brine plants is not far from 5000 barrels, though the present demand will not permit the works to run at their full capacity.

The Kansas salt beds extend from Ellsworth and Saline counties southward to the southern line of the state, and in breadth cover from two to three counties, and there is evidence of salt outside of this area. The state holds third rank, after New York and Michigan.

GYPSUM.

Often associated with salt is found the sulphate of lime, or gypsum, which is burned into plaster of Paris or cement wall plaster. In this manufacture Kansas has first rank among the states, on account of the high quality of the materials and the skill in manufacturing. Sixty thousand tons are used a year, and the value of the product is $263,000.

The gypsum deposits form a belt tending northeast-southwest across the state. The belt of exposed rock varies in width from five miles at the north to fourteen in the central part, and thirty-six miles near the southern line, with a length of nearly 230 miles. This area is naturally divided into three districts: The northern or Blue Rapids area, in Marshall county; the central area, in Dickinson, Marion, and Saline counties; the southern or Medicine Lodge area. These

deposits have been described in detail by the writer, forming volume V of the University Geological Survey reports.

The first deposits of gypsum rock worked in the state were in the northern area, where, in 1872, at Blue Rapids, the Coon brothers built a frame shed on the Blue river and commenced the manufacture of plaster of Paris in a five-barrel kettle heated by a stove. Prosperity seems to have attended their work, for three years later they built a stone mill on the west bank of the river, using the water-power, probably the best in the state, for grinding. This mill, though no longer in use, is still standing, a monument to the opening of a great Kansas industry. The mills in this area and one in the central area use the massive white gypsum rock, while the others in the central area use the loose gypsum earth, which is known as agatite, aluminite, and the like. This earthy variety was worked at Gypsum City, Rhodes, and Dillon, and is now used at Burns, Marion county, Mulvane in Sumner, Springvale in Barber, and Longford, Clay county.

The Medicine Lodge area, with its continuation southward into Oklahoma and Texas, forms one of the largest gypsum deposits in the United States. It is traversed by the Santa Fe railroad, and there are only two small mills located there at the present time. Near the town of Medicine Lodge gypsum rock caps the hills as a layer twenty-five feet in thickness, protecting the underlying soft red clays and shales, thus causing a most rugged topography, often likened to the "Bad Lands" of the Northwest.

The term "low, monotonous prairies of Kansas" has no application to the gypsum belt. When the setting sun reflects its light against the red shales crowned by the white gypsum rock, it forms a scene of beauty which attracts the attention of every traveler through that region. The cañons, often 200 feet in depth, are dry during most of the year, but after a summer thunderstorm they are filled with a tumultous flood of sand-laden waters.

In the Eastern states the gypsum rock is ground mainly for fertilizer, but in Kansas it is ground and burned into plaster of Paris for casts, molds, and white finish for walls. This plaster sets in a very few minutes; but it is possible, by adding certain mixtures, to retard the set four to six hours, and the resulting product is sold under the name of cement wall plaster. This forms a hard, firm wall, which dries rapidly and is nearly fire-proof. Some of the large buildings in Chicago and Kansas City have used 2000 and 2500 tons of Kansas plaster, and the demand is increasing each year as the advantages are recognized.

CLAY.

Even the dust under our feet has a value, especially if we are standing in certain places in the state. Earth, mud, or, to speak more technically, clay, which has been properly fashioned, and has emerged from the flames, passes through the hands of the mason into stately architecture. The total value of clay products in the United States is about sixty million dollars, of which one-half represents building brick. This brick would make a walk ten feet in width around the entire globe.

One of the clay industries which has made remarkable growth in the last few years is the manufacture of vitrified brick for street paving. This industry has become especially important in southeastern Kansas, at Pittsburg and the towns in the gas belt. There are now thirteen factories of paving and building brick—three at Iola, two at Chanute, and one in Humboldt, Cherryvale, Coffeyville, Independence, Neodesha, Pittsburg, Girard, and Columbus. Other large plants are found at Atchison, Lawrence, and Topeka.

Common building brick were about the earliest clay products made. The materials were wide-spread, and no great skill is required in their manu-

facture; so that brick-kilns and yards are familiar objects. Many towns in Kansas have such kilns, either in operation or abandoned after they had supplied the home trade. The tough gumbo clays are now burned for railroad ballast at a number of places in the state, on account of its cheapness, and its dustless and elastic properties. In Missouri this industry *alone* amounts to one million dollars annually. There is a large pottery at Coffeyville, and a roofing-tile works is nearing completion at Cherryvale. There are deposits of fire-clay which have not as yet been developed. The total value of Kansas clay products is over $400,000 a year, and over half of the value is in building brick, and about forty-five per cent. paving brick.

HYDRAULIC CEMENTS.

The ordinary limes will not set under water; and when they are exposed to aqueous or water action, become disintegrated. It was early discovered that certain limes would become hard even under water, and they were called hydraulic limes or hydraulic cements. Where the lime rock is burned directly into cement, the product is called natural cement; but where a mixture of limestone and clay or shale is used, the cement is called artificial or Portland, so named from its resemblance to the famous Portland stone of England, used in Westminster Abbey. The United States leads the world in natural-cement manufacture. In Kansas we have a deposit of natural-cement rock equal to the best in this country. This is located near Fort Scott, where there are two companies, with two mills having a daily capacity of 850 barrels of cement. This cement is held in high favor in Kansas City, and has a large market in all the surrounding states, and the Kansas demand is increasing.

The impression among our contractors that Fort Scott cement is inferior to other brands of natural cement is not supported by tests or by experience. The strength of this cement after seven days has been shown to be greater than any other natural cement made in other states.

For many kinds of work, the Portland cements are preferred to the natural. It has not been many years since all of this product was imported from England and Germany; but now it is made at a number of places in this country. Imports of cement have been decreased thirty to fifty per cent. in the last three years; the capacity of American plants has doubled.

The writer, three years ago, made a report of cement locations in Kansas for the Santa Fe industrial department, and recommended a location at Iola. Two years afterward the Portland Cement Company broke ground for one of the largest cement mills in this country, and on the 16th of last June the first cement was made at this mill. Over 1000 cars of building material and machinery were brought in for the four large, fire-proof buildings. Gas is used a direct motive power in the largest gas-engines of the West. There are six 350-horse-power Westinghouse gas-engines, and three 150-horse-power, or a total of 2500 to 3000 horse-power.

BUILDING STONE.

Only two kinds of rock are quarried in Kansas for building stone—limestone and sandstone. About one-half of the limestone of our country, according to value, is burned for lime, and even more is used for building and road material. The Kansas product is used mainly for the latter purposes. Most of the production comes from near the towns of Manhattan, Atchison, Leavenworth, Topeka, Strong City, Cottonwood Falls, Marion, Augusta, Winfield, Arkansas City, and Fort Scott. The largest quarries in the state are at Strong City and Cottonwood Falls. Sandstone is found in all parts of the state in greater or less amount, but the productive portions are in the southern and northwestern parts of the state.

This review of the Kansas mineral resources should give us a higher opinion of our state. The record of the past is one in which we can well take pride, and it is to be hoped that this is but the beginning of greater things to come. New mills are now building, new deposits are now being uncovered, and progress is sure to follow.

THE FLINT HILLS OF KANSAS.

BY J. R. MEAD, WICHITA.

Read before the Academy December 28, 1900.

In this article I shall not attempt to give the geology of the Flint hills. I simply give my observations of years past in a general way.

The so-called "Flint hills" extend through the counties of Chase, Butler, Cowley, and the northwest part of Greenwood, and south through the Kaw reservation, where they merge into sandstone. Their summits are in range 8 east of the sixth principal meridian. North of the Cottonwood they appear to merge into the general line of the uplands. The same strata of rock probably extend northward through Morris and Wabaunsee counties. These hills are the culmination and eastern end of the Upper Carboniferons formation, which, rising toward the east on these hills, reach a general altitude of 1600 feet. In Butler county the eastern declivity is abrupt, and the many ravines descend sharply to the valley of Fall river. From Beaumont, on the summit, to the mouth of Fall river, a distance of fifty miles eastward, the fall is 800 feet. The Flint hills are the result of erosion and not an anticline. In the general wearing down of the various strata once overlying Kansas, nature here formed layers of hard, solid, silicified limestone, effectually stopping the further progress of erosion, as did the massive gypsum which caps the hills of Barber and Comanche counties. This wearing away continued on either side, until the valley of Fall river was formed on the east and the Walnut river to the west, leaving these hills high in the air; yet the approach from the west is so gradual and uniform it is hardly noticeable. A fine exposure of this limestone is found along the bluffs bordering the south fork of the Cottonwood on the east, where along the slopes of the ravines may be seen blocks of stone ten by fifteen to twenty feet, and eighteen to twenty inches in thickness, on which the tooth of time makes exceedingly small impression.

The name "Flint hills" is misleading. These hills, or high table-lands, gently sloping to the west, contain no strata or ledges of flint. The thin deposit of chert, styled flint, found on the surface of the summits of the hills in Butler county, is derived from nodules of that material occurring in the limestone rock of that locality, the superimposed layers having weathered away, leaving the indestructible flint nodules on the surface. These have broken into fragments by the action of the elements, fire being an active agent. In the Walnut river, above Arkansas City, are large beds of this broken flint, washed down from the hills and tributary streams in time of flood, in which are found many buffalo bones and skulls. Indian arrow points are often found along the railroad tracks, where this gravel is used for ballast.

In the Kaw reservation, on the summit of the hills are ancient quarries where some primitive people obtained flint nodules from which to make arrow-heads, spears, and knives. To the west there is no stone in Kansas or the territory suitable for that purpose.

There is no lead or zinc or other valuable metals in these hills, as many sup-

pose, nor oil nor gas. If they were within the boundaries of a coveted Indian reservation they would contain all these, also abundance of gold and other desirable things, in the imagination of boomers and squatters.

There is a thin vein of coal of little value underlying these hills. On Coal creek, a tributary of Jacobs creek, ten miles southwest of Emporia, it was mined for neighborhood use thirty-five years ago. The same vein of coal is found in some of the streams or ravines coming out of the Flint hills on the west, tributary to Fall river, in Greenwood county. It is possible pockets of this coal may be found of value.

The soil of these hills is rich in lime and organic matter; affords abundant nutritious grasses; bleak in winter; and in summer affords the finest pasture for herds of cattle and sheep. Thus these hills contribute their share to the food supply of the nation.

FOSSIL PLANTS IN THE PERMIAN OF KANSAS.

BY E. H. SELLARDS, UNIVERSITY OF KANSAS, LAWRENCE.

Read before the Academy December 29, 1900.

The discussion of the age of the Upper Paleozoic of Kansas has rested heretofore on the evidence of animal fossils alone; but a little more than a year ago Mr. Charles Sterling, of the University of Kansas, found near his former home, in southwest Dickinson county, some well-preserved fossil plants, and brought a small box with him on his return to the university. They proved of much interest, and in the following October the author, under direction of the University Geological Survey, spent a week collecting at the locality; and again, during the past summer, was permitted to spend three weeks in the region, thus making a more complete collection. In August, 1900, I learned through Professor Jones, of Salina, that Mr. Charles Polleys had found some plants in the shales along the Smoky Hill river just east of Salina, and that Professor Jones had also obtained a few plants from the same shales. Later, I had opportunity of visiting this locality in company with Professor Jones.

The plants of both localities are very near the top of the highest Permian found in that region. The plant horizon of Dickinson county is separated by only about twenty feet of alternating thin layers of impure limestone and shales from the overlying Cretaceous sandstone. Below the plant stratum thin limestones and shales occur for a thickness of ten to fifteen feet, with a dark-blue shale below, apparently of considerable depth, the lower part of which is streaked with layers of gypsum and dolomite.

The first plants collected, those by Mr. Sterling, were obtained at the head of one of the west tributaries of Turkey creek, three and one-half miles south of Banner City. From this place I was able to trace the plant stratum a mile north, finding plants at various places. To the south I found many exposures for about two miles, and traces of plants again in Marion county, six miles south. The same stratum would probably be found along the hills near the top of the Permian through the northwestern part of Marion county. To the west the plant-bearing stratum dips under the Cretaceous, but is exposed wherever the streams cut deeply. On Holland creek, three miles south of Carlton, some good plants were obtained. The plant-bearing stratum is to be looked for in the deeper creeks as far west as Salina, and doubtless search throughout this region would discover some good localities for collecting.

Whether the shales at Salina are the same as the blue shales underlying the

plants in Dickinson county cannot at present be decided, since no attempt has been made to trace the connection between them. They are alike in appearance, and both have layers of gypsum streaked with dolomite at their base. Above the shales at Salina thin layers of limestone occur, containing fragments of plants similar to the plant-bearing limestone farther to the east. Professor Prosser referred the section here southeast of Salina doubtfully to the Wellington shales, because of the absence of fossils. It is possible, however, that the plant-bearing shales of both localities will prove the same, and belong to the upper part of the Marion. Of the three recognizable species of plants found at Salina, two are found also at the Dickinson county locality.

The best plants obtained so far are those from the Dickinson county localities. They are found here preserved in an impure limestone, very variable in its lithological characters, usually very hard, sometimes concretionary, or again grading into sandstone. In places numerous concretions are found; these are circular in outline, flattened, from a few inches to two feet or more across, and break with difficulty. The plants contained in them have the details well preserved, but are usually fragmentary. In other places, the plant-bearing stone is continuous, for some distance at least, varying in thickness from two or three to fourteen inches. The plants here are more complete.

The plants from the Kansas Permian are of the more interest since very few plants of this age have been found in America. Some poorly preserved fragments from Fairplay, Colo., plants from the Permian or Permocarboniferous of West Virginia and Pennsylvania, and a few from Prince Edward island, Nova Scotia, are the only other localities from which Permian plants have been reported in America, except fossil wood from Cowley county, Kansas. There are, in the collections so far made, some twenty-six or twenty-seven determinable species, distributed in fourteen genera. The plants indicate unmistakably the true Permian age of the formation in which they are found. Many of the species are characteristically Permian, and only a very small proportion of the species identical with Upper Carboniferous species. The genera are naturally more closely related to those of the Carboniferous. The proportion of new forms is naturally large, owing to the few Permian plants that have been described from this country. A new genus of ferns, including five species, makes up a very considerable element of the flora. I have described this genus in the July (1900) number of the Kansas University Quarterly, vol. IX, p. 179, under the generic name *Glenopteris*.

The Cretaceous, lying directly over the Permian, is also plant-bearing—a peculiar coincidence. Fragments of petrified wood weathered out of the softer sandstone are scattered very generally over the surface. Both wood and leaves occur together in dark shales on the Sterling ranch, east branch of Holland creek. I have not attempted a specific determination of the small box of leaves collected here; but the general appearance of the plants is unlike that of the Dakota flora, being more suggestive of Lower Cretaceous plants.

V. ASTRONOMY.

THE CORONA OF THE SUN.

BY EPHRAIM MILLER, UNIVERSITY OF KANSAS, LAWRENCE.

A lecture delivered before the Academy at its annual meeting, at McPherson, December 29, 1899.

Prof. C. A. Young, perhaps the most competent authority upon solar phenomena, writing about the sun's corona, says: "We must evidently wait awhile for the solution of the problems presented by the beautiful phenomenon. Possibly the time may come when some new contrivance may enable us to see and study the corona in ordinary daylight, as we now do the prominences. The spectroscope, indeed, will not accomplish the purpose, since the rays and streamers of the corona give a continuous spectrum; but it would be rash to say that no means will ever be found for bringing out the structures around the sun which are hidden by the glare of our atmosphere. Unless something like this can be done, the progress of our knowledge must be very slow, for the corona is visible only about eight days in a century, in the aggregate, and then only over narrow stripes on the earth's surface, and but from one to five minutes at a time by any one observer."

Sir Robert S. Ball, in "The Story of the Sun," says: "Such is an outline of the facts known to us with regard to the corona; and it must be admitted that our information is at present of a somewhat meager description. We can only hope that the attempts to photograph the corona without having to wait for a total eclipse may ultimately prove successful.

"Doubtless many of our perplexities would vanish if a series of observations taken at brief intervals were certainly available. We might then expect to gain information regarding the changes in the corona, which it seems absolutely certain are in progress. We might expect, too, that some satisfactory evidence might be forthcoming as to the actual character of the material to which the coronal light is due."

In Langley's splendid book, "The New Astronomy," we read: "Outside all is the strange shape which represents the mysterious corona, seen by the naked eye in a total eclipse, but at all other times invisible even to telescope and spectroscope, and of whose true nature we are nearly ignorant from lack of opportunity to study it." On page 40, the same author says: "The sun went out as suddenly as a blown-out gas jet, and I became as suddenly aware that all around there had been growing into vision a kind of ghostly radiance, composed of separate pearly beams, looking distinct each from each, as though the black circle where the sun once was bristled with pale streamers, stretching far away from it in a sort of crown. This was the mysterious corona, only seen during the brief moments while the shadow is flying overhead."

The French astronomer, Flammarion, says, in his "Popular Astronomy": "What, then, is the corona? It is probably a region in which is found a variable quantity of detached particles, partially or wholly vaporized by the intense heat to which they are exposed. But how can these particles be supported in these burning heights? To this question we are already able to give three replies: *(1)* The matter of the corona may be in a state of permanent projection, being

composed of substances incessantly darted out by the sun and falling back on him. (2) The coronal substance may be more or less supported in the solar heights by the effect of a calorific or electrical repulsion. (3) Finally, the corona may be due to clouds of meteors, aerolites circulating around the sun in his immediate vicinity. All these explanations are perhaps in part true."

In Proctor and Ranyard's "Old and New Astronomy" we read as follows: "But it is evident on the one hand that no simple theory can be advanced in explanation of the phenomena of solar appendages manifestly complex and varied; and on the other, that the details of coronal structure and of coronal phenomena present problems far too difficult to be as yet solvable."

Miss Clerke, in her "History of Astronomy during the Nineteenth Century," says: "The corona is properly described as a solar appendage, and may be conjecturally defined as matter in a perpetual state of efflux from and influx to our great luminary, under the stress of electrical repulsion in one direction and of gravity in the other. Its constitution is of a composite character. It is partly made up of self-luminous gases, chiefly hydrogen, and the unknown substance giving the green ray, '1474,' partly of white-hot, solid or liquid particles, shining with continuous light, both reflected and original. The coronal materials must be of inconceivable tenuity, since comets cut their way through them without experiencing sensible retardation. Summing up what we have learned about the corona during some forty-five minutes of scrutiny in as many years, we may state, to begin with, that it is *not* a solar atmosphere. It does not gravitate upon the sun's surface and share his rotation, as our air gravitates upon and shares the rotation of the earth; and this for the simple reason that there is no visible growth of pressure downward in its gaseous constituents; whereas, under the sole influence of the sun's attractive power, their density should be multiplied many million times in the descent through a mere fraction of their actual depth."

It is easily seen from the preceding extracts that the corona of the sun has been visible only on those rare occasions when solar eclipses are total; and the very short period of time during which a total eclipse lasts at any given point upon the earth's surface renders any examination of the corona a very difficult operation. Since the introduction of the camera and the spectroscope as adjuncts in all solar research, the amount of time and labor devoted to such work has been multiplied more than twofold. All the great observatories of the world are systematically engaged in trying to solve the mystery of the corona. Mountain peaks, clear skies and rare atmospheres have been sought for, and expensive trips to far-away lands have been undertaken, in order to determine once for all what this wonderful thing may be which persists in withholding from the inquisitive eye its secrets and its nature. Men have gone half way round the globe to witness for one, two, or six or seven minutes at most, the most beautiful object visible in the solar system. The question naturally arises, Is it possible, or will it *ever* be possible, for the human eye, with or without any kind of instrument, and at *any* time, to look upon and examine at leisure such a glorious appendage as that of the sun's corona? Will this nineteenth century, so full of splendid achievement in every field of scientific research, add to its other honors that of having made it possible, in the absence of a total eclipse, to see the corona? All efforts hitherto made have been without avail; have utterly failed.

In 1866 Mr. Lockyer, and in 1868 Janssen, made it possible for one to see at any time of day, when the sun is above the horizon and not obscured by clouds, the so-called "protuberances" or "prominences" that up to that time had been ...ysterious as the corona is now. Miss Clerke says: "The eclipse

of 1868 is chiefly memorable for having taught astronomers to do without eclipses, so far, at least, as one particular branch of solar inquiry is concerned. Inspired by the beauty and brilliancy of the variously tinted prominence lines revealed to him by his spectroscope, Janssen exclaimed to those about him, 'Je verrai ces lignes-là en dehors des eclipses!' On the following morning he carried into execution the plan which formed itself in his brain at the time of the eclipse."

More than a year ago an idea took possession of my brain that there must be some method by which the corona of the sun may be rendered visible at any time between sunrise and sunset, atmospheric conditions being favorable. In the latter part of April, 1899, I secured three strips of pine lumber, each about six or seven feet long, and of a uniform thickness of three-fourths of an inch. The strips were fastened to the outside of the tube of a Clark telescope of six inches object-glass, separated from each other by a distance of 120 degrees. Ordinary wrapping twine was used with which to make the strips secure and firm in their position. They were so placed that about three feet of each one was allowed to project beyond and in front of the object-glass. This done, a cardboard, sufficiently heavy, was cut into the form of a circular disk of seven inches diameter. Upon the inside of the circumference of the disk, and as close to the limb as possible, three small holes were pierced, through which pieces of fine flexible wire were put, and these were tied around the pine strips. By this arrangement the cardboard disk—an artificial moon—could be securely held in position, and by slipping the wires forward or backward, as might be necessary, the disk could be made to hide completely the entire face of the sun. It was expected and hoped that the effect would be the same as in the case of a true solar eclipse; that is, that the solar appendages would be revealed. All things being ready, the telescope mounted firmly upon the tripod, the pine strips fastened, and the cardboard moon put at a suitable distance from the object-glass, on the afternoon of May 3, 1899, the first trial was made; an observation was taken. The face of the sun being completely obscured, bright radiations were seen to issue from the limb of the artificial moon in great numbers. These radiations were carefully scrutinized, but it was soon made apparent that they were nothing but streaks of light, of a decidedly brassy appearance, reflected from the inside of the telescope, the barrel of which was made of brass. The cardboard moon was now shifted to a point a little farther away from the object-glass. The result was still the same—the brassy streaks, and all else. During all this time, and in spite of every effort to prevent it, the barrel of the telescope was flooded with light that poured into it from the surrounding atmosphere. Just here seemed to be the difficulty, the light came into the telescope apparently from everywhere, past the limb of the false moon.

For over an hour slight changes were made in the position of the false moon, at intervals of from five to six minutes each, at one time to a place nearer the object-glass, at another, to a point farther away; but all to no effect; the results were invariably the same, save that the brassy streamers were modified accordingly. Matters were becoming monotonous and rather disheartening, so much so that the question arose whether the observation should be prolonged or given up as a flat failure. The determination to succeed, or know the reason why success should not be attained, prolonged the work for some time longer. The time passed in shifting the false moon, readjusting the pine strips, keeping the telescope in proper position, straining the eye in order to see the sight, should a revelation be made; yet nothing was seen but the brassy reflections from the telescope itself, which seemed to be dancing and laughing as if in very mockery at every attempt to succeed. More than two hours had passed, and the goal to be

Observation of supposed corona of the sun without an eclipse.

reached was apparently as far off as ever. The observer was quite disheartened and discouraged, and about ready to give up in despair. In such a frame of mind, and quite willing to give it up as a bad job, suddenly and unexpectedly the false moon, for some reason or other, changed its position slightly, so that apparently its surface and the surface of the object-glass were no longer parallel to each other. Whether the lack of parallelism was a fact or not cannot now be determined. The effect produced was that the barrel of the telescope seemed to be completely filled with absolute darkness, the brassy streamers vanished, and along the upper right-hand limb of the false moon appeared, in all their beauty and soft light, the coronal streamers. There was no mistaking the vision. It was the genuine corona itself; a thing of beauty, and a glorious recompense for the time and labor that had been expended.

An attempt to change the position of the telescope so as to hold the sun in the field resulted in destroying the vision, and the coronal streamers disappeared from view. The following is a *facsimile* of a hand-made drawing of the corona, as seen on the afternoon of May 3, 1899. It is not a complete coronal form, for the reason that the cardboard disk extended beyond the limb of the sun, and prevented a view of the streamers other than as represented.

Several cardboard disks, one six inches in diameter, one seven and another eight inches in diameter were made, and used at varying distances. A great many obstacles had to be met and surmounted in preparing for the work, and great care had to be exercised in handling the apparatus. The telescope used was mounted on a tripod, and was exposed to the action of the wind. There was no driving-clock attachment; so that every movement had to be made by the observer, thus rendering the labor so much the more difficult. Other observations were taken in May and in June, but, on account of ill health, the observations had to be suspended during the summer, and there has been no opportunity since to resume them.

But that the corona of the sun was seen on the 3d of May, 1899, a day upon which there was no eclipse of the sun, either partial or total, can scarcely admit of doubt. There is a possibility that it may have been a vision of something else—an optical illusion, an "*ignis fatuus*," or a dream.

At the moment when the picture was sketched, the "apparition" was situated in the vicinity of one of the poles of the sun, and not in the plane of the sun's equator; and so clear and well defined was the shape, and so different from all other appearances, that the conclusion reached by the observer was that it was the corona itself. To be sure, he may have been mistaken, but he thinks not, and it is unfortunate that the observation of May 3 has not as yet been corroborated by other observations. The work will be resumed in the near future.

The difficulty in the case consists not in making an artificial moon, attaching it to a telescope, and locating it at a proper distance from the object-glass, but in flooding the barrel of the telescope with absolute darkness. When that is done, all other difficulties will seem but trifles and will vanish at once. The light of the sun that fills the surrounding atmosphere is the great foe to anything like success, and seems to bid defiance to every attempt. Shut out that light, exclude it entirely from the interior of the telescope by means of a conical hood that will extend some distance over the barrel of the telescope and forward as far, perhaps as the false moon, or further, and with the conveniences and appliances of a modern observatory, the result may be safely predicted—the corona will be made visible.

In conclusion, if the corona was seen upon the day mentioned, when there was no eclipse of the sun, as described in the foregoing, I think I am justified

in saying that the same thing can be done again and again, upon any clear day, during the hours of sunshine, no clouds interfering, and other atmospheric conditions being suitable, and the question as to the possibility of astronomers seeing and studying the greatest mystery of the sun at any time will be settled once for all.

VI. ARCHEOLOGY.

ARCHEOLOGY OF CATALINA ISLAND.

BY J. R. MEAD, WICHITA.

Read before the Academy December 29, 1900.

Out in the Pacific ocean, 20 to 100 miles off the coast of southern California, scattered along north and south, are the "channel islands." They are of igneous formation, in places volcanic, porphyry predominating, with extensive ledges of sandstone. The past summer I spent a short time on Santa Catalina, the most interesting of these islands. It is nearly all mountainous, arising abruptly from the ocean. It is sixteen miles in length by five or six in width, with an area of 55,000 acres. If it were spread out flat it would be two or three times as large.

It is owned by the Baring brothers, title coming from a Spanish grant. There is no more beautiful spot in America than the Bay of Avalon, near the southeast end of the island. In traveling over the island I found abundant evidence of ancient inhabitants, who disappeared early in this century and are lost to history. The first Portuguese ship sailing up the coast discovered the island, about A. D. 1530, and anchored in the Bay of Avalon for several weeks. They found the island inhabited, and a large village on the shore of the bay. The people were inoffensive, hospitable, and friendly.

The other islands also contained a large population of the same people, it is said, of different language and customs from the numerous people on the mainland. They made boats of skins (there being no timber of consequence on the island), with which they traversed the stormy ocean from one island to another, perhaps 100 miles apart.

In no other spot on earth was marine life more abundant, from whales down to sardines. The waters swarmed with fish; herds of seals and sea-lions covered the outlying rocks and beaches. Under water, the rocks were covered with shell-fish. The abalone seemed to be the favorite food of the natives, as shell mounds ten feet deep, locally called "clambakes," mostly of abalone shells, testify. To my surprise, I found these clambakes on the top of the mountain ridges. In a placed called "Indian caves" were tons of heavy shells, carried there for food.

The northern slopes of the mountains in places were covered with a low scrub oak, not averaging over ten feet in height. Perhaps the natives made their camps high up during the acorn harvest. Heavy stone mortars are found about these clambakes, or camps, which appear to have been used through long periods of time.

The town of Avalon, a noted pleasure resort, is built on an ancient village site; and in excavating cellars quantities of stone vessels, ashes and shells are found. These clambakes appear to have been utilized as burying-grounds, as large numbers of skeletons, buried in rows or circles, are found in them.

On the eastern center of the island are quarries of steatite, or soapstone, out of which the natives had cut thousands of vessels *in situ*, a nest of vessels being cut out of one spot, ranging in size from half a pint up to ten gallons. These vessels are used to cook their food. Their mortars were made of granite boulders. Some of these vessels, made of the hardest of known rocks, were almost as true

as if turned in a lathe. Tons of these vessels have been carried away from this and other islands. I was told that in a secluded ravine, in the interior of the island, known to but few, a car-load of these stone vessels lie on the surface, most of them broken.

There are no stone spears, arrows or axes found on the island, or very few, as there were no land animals except foxes, of a variety peculiar to these islands. The natives found bone to answer their purpose; rude knives of stone were common; in fact, the natives could procure all the food they required by a curious provision of nature. The waters abounded with flying-fish; they rise out of the water when disturbed, and sail with the wind for 200 or 300 yards. Great schools of tunas, white bass and yellowtails surround the bays, driving the smaller fish toward the shore. The flying-fish, in escaping, land far up the beach, where the natives could pick them up at their leisure.

It is said that the natives worshiped the sun. I saw what was said to be a picture of the sun painted in a cave, with other designs. They were too ancient and indistinct for me to decipher. The early mission fathers sent an expedition to the island to destroy a so-called temple in which the natives worshiped.

When or how these people disappeared or perished is not known to the people now living on the coast. There is a tradition that long ago the Russians, trading for furs along the Alaskan coast, furnished the natives of that country guns and taught their use, and employed them as hunters. In the course of time they worked down along the coast of California and discovered the Channel islands, which abounded with sea-otter, the most valuable of all furs. The natives of Catalina and the neighboring islands used these skins for clothing and bedding. This excited the cupidity of the Russians, who the next year brought down several hundred of their hunters, armed with guns, and left them on the islands. Finding the natives rich in furs and powerless to defend themselves, they exterminated them. This is the story. On St. Nicholas island, eighty miles out in the ocean, a sailor of Avalon said to me he counted thirty skeletons in a row, which the violent sandstorm had uncovered, the left temple of each broken in.

Out of the drifting sands of this island boat-loads of stone implements are taken. One hundred and fifty stone mortars were taken to the World's Fair, at Chicago.

Here we find once populous islands on our coast, of the origin of whose people or their fate we know nothing. Perhaps a pestilence destroyed them, as it did many thousands of natives on the upper Missouri river in 1837.

The statement, so often seen emanating from semiofficial sources, that there are as many Indians now in the United States as when the continent was discovered, and that they are not decreasing in numbers, is utterly at variance with the facts. The remaining 250,000 Indians are the remnant of three millions, who inhabited the territory of the United States in A. D. 1500. When first known, early in the century, the Kaw Indians numbered between 5000 and 10,000, and when I first knew them they numbered 1500; now there are but 250 left.

JAMES B. QUINTARD.

VII. NECROLOGY.

JAMES BRADLEY QUINTARD

Was born in Norwalk, Conn., October 21, 1839, and lived there until about ten years of age, when he moved with his parents to Mt. Vernon, Ohio. He was one of nine children—four girls and five boys.

When about twenty-one he met and married a Miss Maddie Watkins. In the summer of 1860 he brought his bride to the wild prairie ten miles west of the infant city of Topeka, and has since lived on the home selected then. His family consisted of eight girls.

Having had few educational advantages when a boy, he applied himself to various studies while providing for his growing girls, and in this way became proficient in mathematics, navigation, geology, and conchology. At one time he helped Prof. F. W. Cragin make a collection of the shells of Kansas for Washburn College.

Mr. Quintard lost his wife in the fall of 1896, and the following June his youngest daughter, a girl of nineteen, died. Two years later another daughter was laid away.

He died at his home near Silver Lake, December 17, 1899. His large collection of land, fresh-water and marine shells has been presented by his daughters to the Academy of Science, and is on exhibition at the state capitol.

COL. WILLIAM TWEEDDALE,

Civil and hydraulic engineer, and for many years city engineer of Topeka, was born in Beith, Ayrshire, Scotland, in 1823, and came to this country with his parents when nine years of age. He entered the Rensselaer Polytechnic Institute, Troy, N. Y., in 1850, and graduated as a civil engineer in the class of 1853. After one year's practice in railway construction, he returned to the institution as instructor in field-work. In 1855 he removed to Chicago, where he engaged as a bridge engineer and contractor.

At the outbreak of the civil war he raised a company of volunteer engineers at Dubuque, Iowa, and was subsequently breveted colonel of volunteers for his services in the "march to the sea" campaign. In the New Madrid compaign he was in command of the expedition; designed the appliances and successfully constructed the New Madrid canal, which resulted in the reduction of Island No. 10. After the evacuation of Corinth he was given charge of the opening and maintenance of military railways. At Vicksburg he cut a canal by cutting down trees and sawing off the stumps four and a half feet below the surface of the water, through bayous, for the passage of transports from Ducksport to New Carthage, a distance of twenty-five miles. During the siege he was at Haines bluff, in charge of the construction of fortifications in the rear of the army, and in the campaign from Atlanta to Washington had charge of the bridge train for the army of the Tennessee.

In 1867 he removed to Topeka, where he engaged in the practice of engineering and as contractor for public buildings. Through his recommendation the Melan arch bridge spanning the Kansas river was erected. He was first elected to membership in the Kansas Academy of Science in 1872, and had been more or less active in it to the day of his death.

At the time of his death he was engaged in introducing his patented process for the softening and purification of water, to the perfection of which he had devoted thirty years of research and experiment. Among the last work of his life was the preparation of a paper on "The Softening and Purifying of Water by the Tweeddale Process," which was read before the Academy of Science at its annual meeting at McPherson, December 29, 1899. Colonel Tweeddale died in Topeka, November 4, 1900, at the age of seventy-seven years. He leaves a wife and one daughter (Mrs. W. C. F. Reichenbach).

COL. WILLIAM TWEEDDALE.

APPENDIX.

ACCESSIONS TO THE LIBRARY.

JANUARY 1, 1899, TO DECEMBER 31, 1900.

BY B. B. SMYTH, LIBRARIAN.

ALABAMA.

UNIVERSITY.—*Geological Survey of Alabama, Eugene A. Smith, Ph. D., State Geologist:* Iron making in Alabama, 380 pages. Report of the Warrior coal basin, 330 pages. Bulletin No. 6, on clays of Alabama, 220 pages.

CALIFORNIA.

BERKELEY.—*University of California:* Annual reports of secretary, 1899, 127 pages; 1900, 100 pages. Bulletins of the department of geology, vol. I, 428 pages; vol. II, 230 pages.

PALO ALTO.—*Leland Stanford Jr. University:* Contributions to biology from the Hopkins seaside laboratory, articles XVIII-XXII, 354 pages, 23 plates.

SACRAMENTO.—*California State Mining Bureau:* Bulletins: Nos. 13, 14, 15, 16.

SAN DIEGO.—*C. R. Orcutt, Editor:* West American Scientist, Nos. 84-89.

SAN FRANCISCO.—*California Academy of Sciences:* Proceedings, third series, 1899-1900, botany, vol. I, Nos. 6 to 9, 140 pages; geology, vol. I, Nos. 5, 6, 20 pages; mathematics-physics, vol. I, Nos. 5, 6, 191 pages; zoology, vol. I, Nos. 11, 12, 48 pages; vol. II, Nos. 1 to 7, 191 pages; occasional papers, VI, VII, 262 pages.

COLORADO.

COLORADO SPRINGS.—*Colorado College:* Colorado College studies, vols. VII, VIII.

DENVER.—*Colorado Scientific Society:* Bulletins, Nos. 3, 4, 1899; Nos. 1, 2, 3, 1900.

CONNECTICUT.

NEW HAVEN.—*Connecticut Academy of Arts and Sciences:* Transactions, vol. X, 300 pages, 41 plates.

DISTRICT OF COLUMBIA.

WASHINGTON.—*Academy of Sciences of Washington:* Proceedings, vols. I, 339 pages; II, 676 pages.

Biological Society of Washington: Proceedings, vol. XIII, 200 pages.

Chas. W. Smiley, Publisher: The American Monthly Microscopical Journal, vol. XX, 1899; vol. XXI, 1900.

United States Civil Service Commission: Fifteenth annual report, 736 pages.

U. S. DEPARTMENT OF AGRICULTURE.

Department of Agriculture, James Wilson, Secretary: Annual report, 1899, 266 pages; 1900, 70 pages. Circulars: Nos. 21, 22. Year-book for 1898, 800 pages; for 1899, 880 pages, 63 plates.

Division of Agrostology, F. Lamson-Scribner, Chief: Bulletins: Nos. 16-22. Circulars: Nos. 9-26. Farmers' bulletins: Nos. 89, 101, 102, 108.

Bureau of Animal Industry, D. E. Salmon, Chief: Fifteenth annual report, 1898, 647 pages. Bulletins: Nos. 23, 24. Circulars: Nos. 23, 25-30. Farmers' bulletins: Nos. 96, 100, 106.

Division of Biological Survey, C. Hart Merriam, Chief: Bulletins: Nos. 8, 12, 13. Circulars: Nos. 28, 29, 31. North American fauna: Nos. 15, 17, 18, 19.

Division of Botany, Frederick V. Coville, Botanist: Bulletins: Nos. 22-24. Circulars: Nos. 16-29. Farmers' bulletins: Nos. 110, 111, 115. Contributions from U. S. national herbarium: Vol. V, Nos. 4 and 5, pages 145-320, plates XVIII-LXIV; vol. VI, plant life of Alabama, 921 pages, map. Inventory: Nos. 1 and 2. Foreign seeds and plants: Nos. 1 to 1900.

Division of Chemistry, Harvey W. Wiley, Chemist: Bulletins: Nos. 52, 56, 57. Farmers' bulletin: No. 90.

Division of Entomology, L. O. Howard, Entomologist: Bulletins: Nos. 17, 19, 20, 21, 22, 26. Circulars: Nos. 37, 38, 39, 41. Farmers' bulletin: No. 120.

Office of Experiment Stations, A. C. True, Director: Bulletins: Nos. 28, 49, 51, 56-79, 81, 83. Circulars: Nos. 40-44, 82, 84, 85. Experiment station records, vols. X, 760 pages; XI, 500 pages; XII, 201 pages. Farmers' bulletins: Nos. 87, 92, 93, 97, 103, 105, 107, 109, 115, 117, 118, 119.

Fiber Investigations, Charles Richard Dodge, Special Agent: Reports: Nos. 10, 11.

Section of Foreign Markets, F. H. Hitchcock, Chief: Bulletins: Nos. 14, 15, 16, 17. Circular: No. 21.

Forestry Division, B. E. Fernow, Chief: Bulletins: Nos. 17, 22, 25, 26, 28. Progress of Forestry in the United States, by Gifford Pinchot. Circular: No. 22. Report of the forester for 1899, by Gifford Pinchot, pages 93-100.

Division of Pomology, G. B. Brackett, Chief: Bulletin: No. 8. Report: No. 61. Special Report: No. 18. Farmers' bulletin: No. 113. Circular: No. 1.

Division of Publications, George Wilson Hill, Chief: Library bulletins: Nos. 26-29. Senate document: No. 124.

Office of Road Inquiry, Roy Stone, Special Agent: Circular: No. 33. Farmers' bulletin: No. 95.

Division of Soils, Milton Whitney, Chief: Bulletins: Nos. 15, 16. Circulars: Nos. 3, 5, 6. Farmers' bulletin: No. 88. Reports: Nos. 59, 60, 62.

Division of Statistics, John Hyde, Statistican: Bulletins: Nos. 15, 16, 17. Circulars: Nos. 5, 10, 11, 12, 13. Crop circulars, monthly. Report: No. 156.

Division of Vegetable Physiology and Pathology, B. T. Galloway, Chief: Bulletins: Nos. 17, 18, 20, 21, 22. Circular: No. 17. Farmers' bulletin: No. 91.

Weather Bureau, Willis L. Moore, Chief: Bulletins: Nos. 16, 18, 23, 25, 26, 29. Farmers' bulletin: No. 104. Monthly weather review, October, 1898, to September, 1900. Report of the chief of the weather bureau, 1896, 1897, 1898. Daily precipitation at rainfall stations of the United States, for the years 1893 to 1895, part I.

U. S. DEPARTMENT OF THE INTERIOR.

United States Bureau of Education, William T. Harris, Commissioner: Circulars of information. Report of the commissioner for 1898, vol. I, 1280 pages; vol. II, 1360 pages; report for 1899, vol. I, 1252 pages; vol. II, 1270 pages.

United States Geological Survey, Chas. D. Walcott, Director: Eighteenth annual report, 1897, part I; nineteenth annual report, 1899, part I. Monographs: Vols. XXV, 660 pages; XXVI, 260 pages; XXVII, 556 pages; XXVIII, 608 pages; XXIX, 709 pages; XXX, 200 pages; XXXI, 260 pages; XXXII, 892 pages; XXXIII, 402 pages; XXXIV, 489 pages; XXXV, 295 pages; XXXVI, 512 pages; XXXVII, 467 pages; XXXVIII, 817 pages.

Smithsonian Institution, S. P. Langley, Secretary: Annual reports for 1897, 686 pages; 1898, 696 pages. Smithsonian miscellaneous collections: Vol. XXXIX, 430 pages; vol. XL, 1228 pages. Annals of the astrophysical observatory, vol. I, 1900, 266 pages, 32 plates.

Smithsonian Institution — Bureau of Ethnology, J. W. Powell, Director: Seventeenth annual report, 1896, in two parts, 752 pages, 175 plates, 356 figures; eighteenth annual report, 1897, 518 pages, 107 plates, many figures.

Smithsonian Institution — U. S. National Museum, S. P. Langley, Secretary in charge: Annual reports, 1897, part I, 1021 pages; 1898, part I, 1294 pages. Proceedings, vols. XXI, 1899, 934 pages; XXII, 1900, 1060 pages.

U. S. NAVY DEPARTMENT.

United States Lighthouse Board: List of lights and signals of the United States on the Northern lakes and rivers, Pacific, Atlantic, and Gulf coasts.

United States Naval Observatory, Capt. F. V. McNair, U. S. N., Superintendent: Reports of the superintendent, 1899, 1900. Catalogue of stars observed at the U. S. naval observatory from 1845 to 1877, by Capt. Edgar Frisby, U. S. N., 3d edition, 302 pages.

U. S. TREASURY DEPARTMENT.

Bureau of the Mint, Geo. E. Roberts, Director: Report of the director of the mint upon the production of precious metals in the United States, for 1897, 404 pages, 10 plates; for 1898, 313 pages; for 1899, 435 pages, 18 half-tone plates.

U. S. Coast and Geodetic Survey, Henry S. Pritchett, Superintendent: Annual report of the superintendent, 1898, 489 pages, many plates, map in pocket; 1899, 964 pages, many plates, map in pocket. Special publication No. 4, the transcontinental triangulation, 1900, 871 pages, many plates, map in pocket.

ILLINOIS.

CHICAGO.—*Armour Institute of Technology:* Year-book, 1900-'01.

Chicago Academy of Sciences: Fortieth annual report, 1897, 28 pages. Bulletins: Nos. 2, 3, 4, 500 pages, many plates and figures.

Field Columbian Museum: Publication 51, anthropological series, vol. II, No. 4, 10 pages, 11 plates. Publications 39, 43, 48, 50, botanical series, vol. I, Nos. 5, 6, 24 pages, 5 plates; vol II, Nos. 1, 2, 123 pages. Publications 33-36, 44, 53, geological series, vol. I, Nos. 3-8, 144 pages, 16 plates. Publications 30-32, 37, 38, 40, 41, 49, 45-47, zoological series, vol. I, Nos. 11, 18, 104 pages, 16 plates; vol. II, 471 pages, 143 plates; vol. III, Nos. 1, 2, 14 pages, 4 plates. Publications 29, 42, 52, report series, vol. I, Nos. 4-6, 252 pages, 40 plates.

Library Bureau: Public Libraries, monthly, vol. IV, 1899, 472 pages; vol. V, 1900, 488 pages.

University of Chicago, Department of Geology: Journal of Geology, semiquarterly, vol. VII, 1899, 842 pages, many illustrations; vol. VIII, 1900, 800 pages, many illustrations.

PEORIA.—*Fred Boettger:* Bulletin of the Peoria Scientific Association, 1887, 92 pages.

SPRINGFIELD.—*Illinois State Museum of Natural History:* Bulletin No. 12, 69 pages, 5 plates of crinoids, etc.

URBANA.—*Illinois State Laboratory of Natural History, S. A. Forbes, Director:* Bulletin, vol. V, articles VII, VIII, IX, X, XI, 478 pages. Biennial report, 1897-'98, 32 pages, 10 plates.

INDIANA.

BLOOMINGTON.—*J. W. Beede, Ph. D., University of Indiana:* The stratigraphy of Shawnee county; the McPherson Equus beds; notes on Kansas physiography; new fossils from the Kansas Coal Measures; Carboniferous invertebrates, 187 pages, 43 plates; a reconnoissance in the Blue Valley Permian, 12 pages, map.

INDIANAPOLIS.—*Department of Geology and Natural Resources, W. S. Blatchley, State Geologist:* Twenty-third annual report, 1898, 1771 pages, 8 lithograph maps, numerous sketches; twenty-fourth, 1898, 1078 pages, 88 plates, 1 lithograph map.

Indiana Academy of Science: Proceedings, 1898, 298 pages; 1899, 184 pages.

IOWA.

AMES.—*Iowa Agricultural Experiment Station:* Bulletins, Nos. 41, 66 pages; 53, 8 pages.

DAVENPORT.—*Davenport Academy of Sciences:* Proceedings, vols. V, 1885-'89, 370 pages, 2 plates, portrait; VI, 1889-'97, 392 pages, 34 plates; VII, 1897-'99, 280 pages, 17 plates.

DES MOINES.—*Iowa Academy of Science:* Proceedings 1898, vol. VI, 234 pages, 7 plates.

Iowa Geological Survey: Vol. IX, annual report, 1898, 572 pages, 13 plates, 56 figures; vol. X, 1899, 666 pages, 10 lithograph maps, 11 plates, 102 figures.

Iowa Historical Society: Documentary material relating to the history of Iowa; Iowa historical record, vols. XIV, XV, 1899, 1900.

L. H. Pammel, Author: Contributions from the botanical department of Iowa State College of Agriculture and Mechanic Arts, Nos. 10-13.

T. J. Fitzpatrick, Author: The Orchidaceæ of Iowa, 14 pages: ferns of Iowa and their allies, 14 pages.

KANSAS.

ATCHISON.—*E. B. Knerr, Ph. D.:* Midland Monthly, occasional.

EFFINGHAM.—*Lumina C. Riddle, Author:* The embryology of alyssum, 11 pages, 3 plates.

J. W. Beede, Ph. D. (see Bloomington, Ind.)

EMPORIA.—*State Normal School:* Catalogues; twelfth biennial report.

L. C. Wooster, Author: Educational values of the natural sciences. Description of a new species of *Hydreionocrinus*, by S. Weller.

LAWRENCE.—*E. H. S. Bailey, Ph. D.:* Chemistry of gypsum, plaster of Paris, and cement plasters, 36 pages.

Geo. Wagner, Ph. D. (see Ann Arbor, Mich.)

S. W. Williston, Ph. D: Paleontology of Kansas, part I, Upper Cretaceous, 594 pages, 120 plates; part II, Carboniferous and Cretaceous, 516 pages, 73 plates.

University of Kansas: Catalogue of the university for 1898-'99; 1899-1900. The Kansas University Quarterly, series A, vol. VII, 236 pages, 10 plates; vol. VIII, 186 pages, 30 plates; vol. IX, 274 pages, 48 plates.

University Geological Survey, Erasmus Haworth, Geologist: University geological survey of Kansas, vol. V, 183 pages, 30 plates; vol. VI, 516 pages, 73 plates. Mineral resources of Kansas, 1897-'98.

MANHATTAN.—*Kansas State Agricultural College:* Bulletins, Nos. 82-98; annual reports; press reports, occasional.

A. S. Hitchcock, Author: List of plants in my Florida herbarium, 76 pages.

T. D. A. Cockerell and P. J. Parrott, Authors: Contributions to a knowledge of the Kansas Coccidæ.

MCPHERSON.—*Warren Knaus, Author:* Collecting notes on Kansas Coleoptera.

ROCKPORT.—*Elam Bartholomew, Author:* The Kansas Uredinæ, 20 pages.

TOPEKA.—*Adjutant General of the State of Kansas:* Biennial reports, 1899; Kansas troops of the volunteer service, Spanish and Philippine wars.

Auditor of State, Geo. E. Cole, Auditor: Twelfth biennial report, 1900.

State Board of Agriculture, F. D. Coburn, Secretary: Eleventh biennial report, 1898; twelfth, 1900; quarterly reports.

State Board of Health, W. B. Swan, M. D., Secretary: Laws governing practice of medicine in Kansas; what sanitary science has done for American life; relations of state board of health to the public.

State Historical Society, Geo. W. Martin, Secretary: Twelfth biennial report, 1900; Kansas historical collections, vol. VI, 1900.

State Horticultural Society, William H. Barnes, Secretary: The Kansas apple; the plum in Kansas; the peach; the cherry; annual reports, 1898, 1899.

State Superintendent of Public Instruction, Frank Nelson, Superintendent: Twelfth biennial report, 1900.

Secretary of State, Geo. A. Clark, Secretary: Biennial reports, 1898, 1899.

State Treasurer, Frank E. Grimes, Treasurer: Biennial report.

Kansas Fish Warden: Biennial report, 1900.

G. P. Grimsley, Author: Gypsum in Kansas, 28 pages; special report on gypsum and gypsum cement plasters, 144 pages, 30 plates.

T. B. Jennings, Weather Observer: Weather reports, weekly and monthly.

John MacDonald, Editor: Western School Journal, monthly, vol. 36, 1899; vol. 37, 1900.

B. B. Smyth, Author: Plants and flowers of Kansas, 118 pages; floral horologe for Kansas, 4 pages, chart; additions to the flora of Kansas, 24 pages; the Topeka "coal hole," 9 pages, sectional plate; the terminal boulder belt in Shawnee county, 7 pages, map; the buried moraine of the Shunganunga, 10 pages, map.

A. H. Thompson, Author: Comparative dental anatomy, 176 pages, 40 figures.

LOUISIANA.

BATON ROUGE.—*Agricultural Experiment Station:* Thirteenth annual report, 22 pages; bulletin No. 64, 28 pages, 6 plates.

NEW ORLEANS.—*J. C. Smith, Author:* Notes on some new infusoria, 17 pages, plate.

MAINE.

AUGUSTA.—*State Board of Agriculture:* Board bulletins, 1898-1900.

MARYLAND.

BALTIMORE.—*Johns Hopkins University:* Circulars, Nos. 140-142.

MASSACHUSETTS.

BOSTON.—*American Academy of Arts and Sciences:* Proceedings, vol. XXXIV, 1898–'99, Nos. 8–23, pages 148–690, 22 plates, 32 figures; vol. XXXV, 1899–1900, 680 pages; vol. XXXVI, Nos. 1–13, 238 pages.

Boston Society of Natural History: Proceedings, vol. XXVIII, Nos. 10–16, pages 265–424; vol. 29, Nos. 1–14, 322 pages, 14 plates.

Massachusetts State Board of Agriculture: Annual report, 1898, 648 pages, 11 plates; 1899, 582 pages, 7 plates. Report on the work of exterminating the gypsy moth, 72 pages, 12 plates.

Massachusetts Horticultural Society, Robert Manning, Secretary: Transactions, for 1898, 360 pages; for 1899, 308 pages, 14 plates.

New England Zoological Club: Proceedings, vol. I, pages 1–37.

CAMBRIDGE.—*Gray Herbarium of Harvard University, B. L. Robinson, Ph. D., Curator:* Contributions from the Gray herbarium, new series: No. 15, *Eleocharis ovata* and its American allies, and *Scirpus eriophorum* and some related forms, by M. L. Fernald, pages 483–504. No. 16, revision of the genera *Montanoa, Perymenium,* and *Zaluzania,* and synopsis of the genus *Verbesina,* with a key, by B. L. Robinson and J. M. Greenman, pages 505–566; some new species of Mexican phanerogams, by J. M. Greenman, pages 566–678. No. 17, revision of the genus *Gymnolomia* and supplementary notes upon *Cales, Tridax,* and *Mikania,* by B. L. Robinson and J. M. Greenman. No. 18, 38 pages. No. 19, 88 pages.

Merritt L. Fernald, Author: Some antenarias of New England; *Pycnanthemum verticillatum;* two ambiguous loosestrifes from the northern states; illustrated flora of the northern states and Canada, a review; some northeastern species of *Scirpus;* varieties of *Aster* and *Solidago;* recent additions to the Labrador flora; plant names of the Madawaska Indians; three new Western plants.

B. L. Robinson, Author: A new wild lettuce from eastern Massachusetts; a case of ecblastesis and axial prolification in *Lepidium apetalum;* notes on the genus *Bartonia,* by B. L. Robinson, pp. 46–48; a new station for *Galinsoga hispida;* revision of the North American species of *Tephrosia;* revision of the genus *Guardiola,* by B. L. Robinson, pp. 232–235.

Museum of Comparative Zoology at Harvard College: Annual report, 1898–'99. Bulletins: Vol. XXXIII, 167 pages, 112 plates, mostly heliotype; vol. XXXV, 252 pages, 27 lithograph and heliotype plates; vol. XXXVI, Nos. 1–6, 164 pages, 36 plates; vol. XXXVII, Nos. 1, 2, 82 pages, 50 lithograph plates; vol. XXXVIII, No. 1, 50 pages, 38 heliotype plates.

SALEM.—*Essex Institute:* Annual report for 1899, 60 pages; for 1900, 48 pages.

TUFTS COLLEGE.—*Tufts College Library:* Tufts College studies, No. 6, pp. 203–274, 1 plate.

MICHIGAN.

AGRICULTURAL COLLEGE.—*Michigan Agricultural College:* W. J. Beal, Ph. D., author: Michigan Flora, 180 pages; map.

ALMA.—*C. A. Davis, Author:* Botanical notes on Huron county; the flora of Michigan lakes, 10 pages; a remarkable marl lake; a contribution to the natural history of marl, 13 pages.

ANN ARBOR.—*Michigan Academy of Science:* First report, 1894–'99, 180 pages.

University of Michigan: Circulars.

Geo. Wagner, Ph. D.: Pharmacopœia of the United States, 1830, 1860, 1870; pharmacographia, Fluckiger & Hanbury; the principles of pharmacognosy, Fluckiger; reactions, Fluckiger; quantitative chemical analysis, Prescott & Johnson; treatise on chemistry, Roscoe & Schorlemmer, 7 volumes; American Journal of Pharmacy, vols. XLIII to LVIII, 1871–'86, 16 volumes, bound; the same, vols. LIX to LXII, 1887–'90, 4 volumes, in monthly parts; Justus Liebig's Annalen der Chemie, bands 209 to 224, 1881–'84, 16 volumes, bound; bands 225 to 232, 1884–'86, 8 volumes, unbound; General Register, bands 221 to 276, 1884–'93, 1 volume, unbound; bands 278–280, 1893–'94, 3 volumes, unbound; Pharmaceutische Rundschau (Pharmaceutical Review), New York, vols. VII to XVI, 1889–'98, 10 volumes, 4 of them bound. Total, 72 volumes, 52 bound and 20 unbound.

LANSING.—*Michigan State Board of Agriculture:* Thirty-seventh annual report, 1898, 740 pages; thirty-eighth, 1899, 465 pages.

MINNESOTA.

MINNEAPOLIS.—*Geological and Natural History Survey of Minnesota, N. H. Winchell, State Geologist:* Twenty-fourth annual report, 1895-'98, 284 pages. Final report, quarto, vol. IV, geology, 630 pages, 31 colored geological plates, 57 plates of photographic views and sketches, 114 figures.

University of Minnesota—Agricultural Experiment Station: Bulletins, Nos. 60-63, 533 pages, 28 plates; Nos. 65-68, 732 pages; No. 69, 259 pages.

Department of Botany—Conway MeMillan, State Botanist: Minnesota botanical studies, second series, 536 pages, 31 plates, mostly heliotype.

Department of Entomology—Otto Lugger, State Entomologist: Fourth annual report, 1898, butterflies and moths, 279 pages, 24 plates; fifth report, 1899, 259 pages, 16 plates.

Ulysses S. Grant, Ph. D., Author: Geology of eastern end of Mesabi iron range, 14 pages, map; lakes with two outlets, 14 pages; driftless area in northeastern Minnesota, 5 pages; contact metamorphism of a basic igneous rock, 8 pages.

MISSOURI.

COLUMBIA.—*University of Missouri:* Studies, vol. I, No. 1, 80 pages.
University of Missouri Experiment Station: Bulletins 44-47, 87 pages.

JEFFERSON CITY.—*Bureau of Geology and Mines:* Annual report, vol. XII, 409 pages, 13 plates, 6 maps; biennial report, 1898, 68 pages; New year announcement, Jan. 1, 1900, 27 pages.

State Horticultural Society: Fortieth annual report, 412 pages.

ST. LOUIS.—*Academy of Science of St. Louis:* Transactions, vol. VIII, Nos. 7-12, pp. 107-240, pll. XI-XIX; vol. IX, 356 pages, 38 plates; vol. X, Nos. 1-10, 230 pages, 57 plates.

Missouri Botanical Garden, Wm. Trelease, Director: Eighth annual report, 1897, 236 pages, 66 plates; ninth report, 1898, 160 pages, 50 plates; tenth report, 1899, 211 pages, 56 plates; eleventh annual report, 1900, 144 pages, 58 plates.

St. Louis Mercantile Library Association: Fifty-second annual report, 80 pages.

J. B. S. Norton, Author: North American species of *Euphorbia*, 58 pages, 52 plates.

MONTANA.

BUTTE.—*Alexander N. Winchell, Ph. D., Author:* Mineralogical and petrographic study of the gabbroid rocks of Minnesota, 1900, 238 pages, map, and 19 plates.

NEBRASKA.

LINCOLN.—*University of Nebraska, Agricultural Experiment Station:* Bulletins, Nos. 55-67, 304 pages, 2 plates, 92 figures.

University of Nebraska: Bulletins, series IV, Nos. 8-10, 100 pages; series V, No. 2, 88 pages. Graduate bulletin, vol. I, No. 1, 63 pages, 4 plates. University studies, vol. II, No. 3, 28 pages.

Edwin H. Barbour, Author: The home-made windmills of Nebraska, 78 pages, 78 figures.

NEW JERSEY.

NEW BRUNSWICK.—*New Jersey Microscopical Society:* Abstract, 36 pages.

ROSEMONT.—*Dr. G. N. Best:* Various botanical and microscopical papers.

TRENTON.—*Agricultural Experiment Station, B. D. Halsted, Botanist:*

NEW MEXICO.

LAS VEGAS.—*T. D. A. Cockerell, Author:* Three new Aleurodidæ from Mexico; the zonal distribution of Coleoptera in New Mexico, 44 pages.

MESILLA PARK.—*New Mexico College of Agriculture and Mechanic Arts:* Bulletins 24, 28, 92 pages.

NEW YORK.

ALBION.—*Walter F. Webb, Publisher:* The Museum, vols. V, 192 pages; VI, 150 pages.

BUFFALO.—*Buffalo Society of Natural Sciences:* Bulletins, vol. VI, 266 pages, 28 plates, 263 figures.

Grosvenor Library: List of books in library on arts and crafts.

HAMILTON.—*Colgate University, Department of Geology:* Circular of information, No. 7, 1899-1900.

ITHACA.—*M. V. Slingerland, Cornell University:* Bulletins, Nos. 148, 170, 172, 176, 233 pages, 57 figures.

LAKE MOHONK.—Report of fourth annual meeting on international arbitration, 1898, 116 pages; sixth, 1900, 125 pages.

NEW BRIGHTON.—*Natural Science Association of Staten Island:* Proceedings, vol. VII, 1898-1900, 46 pages.

NEW YORK.—*Linnæan Society of New York:* Abstract of proceedings, No. 11, 1899, 36 pages; No. 12, 1900, 12 pages.

New York Academy of Sciences: Annals, vols. XI, 516 pages; XII, 715 pages, 20 plates; XIII, part I, 542 pages, 16 plates. Memoirs, quarto, vol. II, parts I and III, 124 pages, 8 plates.

New York Botanical Garden: Bulletin, vol. I, Nos. 4, 5, pages 171-464, plates 3-12.

Torrey Botanical Club: Bulletin, vols. XXVI, 1899, 659 pages, 23 plates; XXVII, 1900, 660 pages, 25 plates.

ROCHESTER.—*Rochester Academy of Science:* Proceedings, vol. III, part II, pages 151-230; vol. IV, pages 1-64.

NORTH CAROLINA.

CHAPEL HILL.—*Elisha Mitchell Scientific Society:* Journal, vols. XIV, part II, 1897, pages 75-114; XV, 1898, 114 pages; XVI, 1899, 92 pages; XVII, part I, 24 pages.

W. W. Ashe, Author: East American species of *Crataegus*, 10 pages; some dichotomous species of *Panicum*, 8 pages.

NORTH DAKOTA.

FARGO.—*North Dakota Agricultural Experiment Station:* Eighth annual report, 84 pages.

OHIO.

CINCINNATI.—*C. G. Lloyd:* Third report on the Lloyd mycological museum, 1897; fourth report, 1898; a compilation of the Volvæ of the United States, 1898, 24 pages; mycological notes, 1898, 1899, 32 pages; catalogue of the botanical department of the Lloyd library, 1899, 1900, 24 pages.

Lloyd Library, J. U. and C. G. Lloyd: Bulletins, Nos. 1 and 3; reproduction series, No. 1; collections for an essay toward a materia medica of the United States, by Benj. Smith Barton, 1798-1804, 156 pages; No. 2, the Indian doctor's dispensatory, 1812, 120 pages.

Cincinnati Museum Association: Nineteenth annual report, 1899, 72 pages; twentieth, 1900, 68 pages.

COLUMBUS.—*Ohio Academy of Science, Wm. C. Mills, Librarian:* Special papers, No. 3, 75 pages, 5 plates, 3 charts, map.

Ohio State Archæological and Historical Society, E. O. Randall, Secretary: Fifteenth annual report, 29 pages. Archæological and Historical Quarterly, vols. I, 403 pages; II, 582 pages; III, 328 pages; IV, 481 pages; V, 350 pages; VI, 463 pages; VII, 366 pages; all bound; vols. VIII, 488 pages, many plates; IX, Nos. 1 and 2, 252 pages.

Ohio State University—Department Zoology and Entomology: University bulletins, No. 1, 116 pages; No. 3, 24 pages, 2 plates; No. 4, 24 pages; No. 5, 108 pages.

Jas. S. Hine, Author: Panorpidæ of America north of Mexico, 24 pages, 3 plates.

W. A. Kellerman, Ph. D., Author: A foliicolous form of sorghum smut; an Ohio station for *Ampelopsis cordata;* non-indigenous flora of Ohio, 28 pages; fourth state catalogue of Ohio plants, 66 pages; first supplement, 10 pages; edible fungi of Ohio, 8 pages.

Wm. C. Mills, Ph. D.: The preglacial drainage of Ohio, December, 1900, 75 pages, 9 plates and sketches.

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Philosophical Society of Washington.

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Illinois State Board of Agriculture.
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Bloomington—Indiana State University.
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Terre Haute Science Association.

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Hutchinson—Public School Library.
Kansas City, Kan.—Kan. City High School Lib.
Lansing—State Penitentiary Library.
Larned—Public School Library.
Lawrence—Kansas State University Library.
Chemical Department, State University.
Haskell Indian School.
Kansas University Quarterly.
Lawrence City Library.
Leavenworth—Academy of Science Library.
Leavenworth Public Library.
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National Military Home.
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Salina Normal University.
Stockton—Stockton Academy Library.
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Assistant Auditor of State.
Assistant Secretary of State.
Assistant Treasurer of State.
Attorney General.
Auditor of State.
College of the Sisters of Bethany.
Commissioner of Insurance.
Governor of Kansas.
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Harrison School Library.
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Speaker of the House of Representatives.
State Board of Agriculture.
State Board of Health.
State Board of Railroad Commissioners.
State Historical Society.
State Horticultural Society.
State Insane Asylum.
State Labor Commissioner.
State Printer.
State Reform School.
State Superintendent of Public Instruction.
State Supreme Court.
State Treasurer.
Topeka City Library.
Topeka High School Library.
Topeka Philosophical Society.
Washburn College Library.
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Wichita—Fairmount College Library.
Garfield University Library.
Lewis Academy Library.
Winfield—Public School Library.
Southwestern Kansas College.

KENTUCKY.

Louisville—Louisville Library Association.
Polytechnic Society of Kentucky.

LOUISIANA.

New Orleans—New Orleans Academy of Sci.

MAINE.

Augusta—State Library.
Portland—Library Association of Portland.
Portland Society of Natural History.

MARYLAND.

Baltimore—Maryland Academy of Sciences.

MASSACHUSETTS.

Boston—Boston Athenæum, C. A. Cutter, lib.
Boston Public Library, T. F. Dwight, lib.
Boston Scientific Society.
Boston Zoological Society.
Chas. A. Lauriat, publisher catalogues.
Marine Biological Laboratory, Back Bay.
State Library of Massachusetts.
Cambridge—Cambridge Entomological Club.
Harvard College Library.
Harvard Natural History Society.
Lawrence Scientific School, Harvard Coll.
Nuttall Ornithological Club.
Peabody Museum.
Hyde Park—Ornithologist and Oologist.
Lawrence—Lawrence Public Library.
Salem—Am. Assoc. for Advancement of Sci.
Peabody Academy of Science.
Williamstown—Williams College Library.

MICHIGAN.

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Agricultural College—Agricultural Coll. Lib.
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MINNESOTA.

Minneapolis—American Geologist.
Minnesota Academy of Natural Sciences.
Minneapolis City Library.
University of Minnesota Library.
St. Anthony Park—U. of M. Experiment Sta.
St. Paul—St. Paul Academy of Natural Sci.
St. Paul Public Library.
State Library of Minnesota.

MISSOURI.

Columbia—Agricultural Experiment Station.
University of Missouri Library.

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Missouri State Library.
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Kansas City Academy of Science.
Kansas City Public Library.
Sedalia—Sedalia Natural History Society.
St. Louis—St. Louis Public Library.
Washington University Library.

MONTANA.

Helena—Montana State Library.

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Crete—Doane College Library.
Lincoln—Nebraska State Library.
University of Nebraska Library.

NEW HAMPSHIRE.

Exeter—Exeter Natural History Society.

NEW JERSEY.

Newark—Newark Entomological Society.
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Schenectady—Union College Library.
Syracuse—Central Library.
Troy—Rensselaer Polytechnic Institute.

NORTH CAROLINA.

Chapel Hill—University of North Carolina.
Raleigh—North Carolina State Library.
Wilmington—Historical and Scientific Soc.

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OHIO.

Cincinnati—Cincinnati Society of Nat. Hist.
Cincinnati University Library.
Historical and Philosophical Soc. of Ohio.
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Western Reserve Historical Society.
Columbus—Ohio State Library.
Granville—Denison Scientific Association.
Urbana—Central Ohio Scientific Association.

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Eugene City—University of Oregon.
Portland—Library Association of Portland.
Salem—Oregon State Library.

PENNSYLVANIA.

Harrisburg—State Library of Pennsylvania.
Lancaster—Linnæan Scientific and His. Soc.
Philadelphia—American Entomological Soc.
Franklin Institute.
Pennsylvania Geological Survey.
University of Pennsylvania Library.
Wagner Free Institute of Science.
Pittsburg—Pittsburg Library Association.
South Bethlehem—Lehigh University Lib.
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SOUTH CAROLINA.

Charleston—Elliot Society of Science and Art.

SOUTH DAKOTA.

Huron—South Dakota State Library.
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TENNESSEE.

Nashville—Tennessee State Library.
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Austin—Texas State Library.
University of Texas Library.
Houston—State Geological and Scient. Ass'n.

UTAH.

Salt Lake City—Museum of Natural History.

VERMONT.

Burlington—University of Vermont Library.
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WASHINGTON.

Olympia—Washington State Library.
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Societe Linneenne de Lyon.
Societe d'Etudes Scientifiques de Lyon.
Marseilles—Academie des Sciences, Lettres, et Arts.
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